IN TWO SECTIONS—SECTION I

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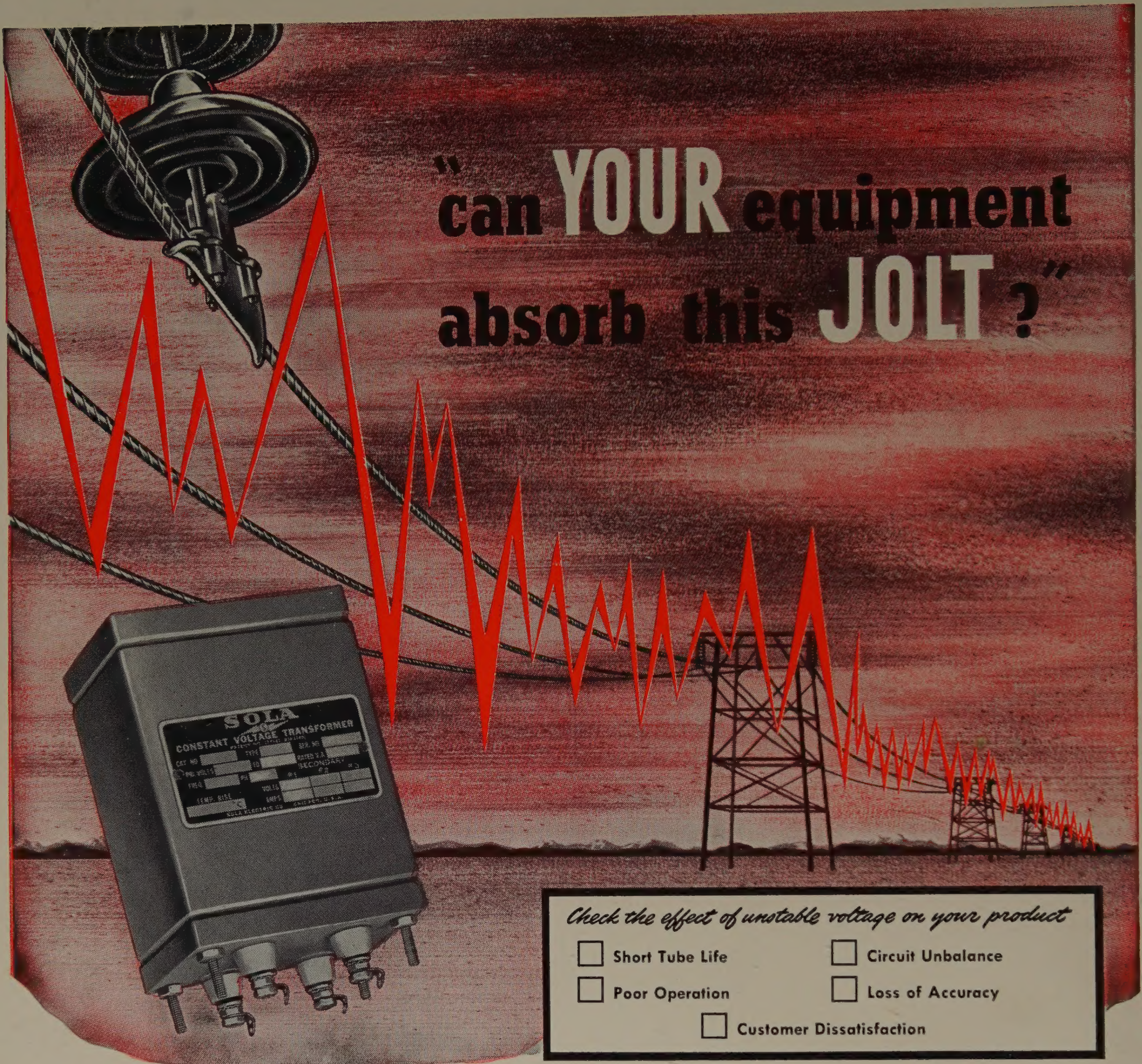
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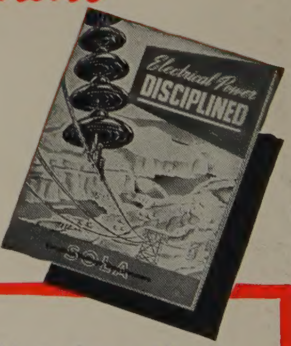

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The Cover: Aerial view of Pittsburgh, Pa., where this year's AIEE winter general meetingis being held. At the lower left is the famous "point" where the Allegheny and Monongahela Rivers join to form the Ohio River.

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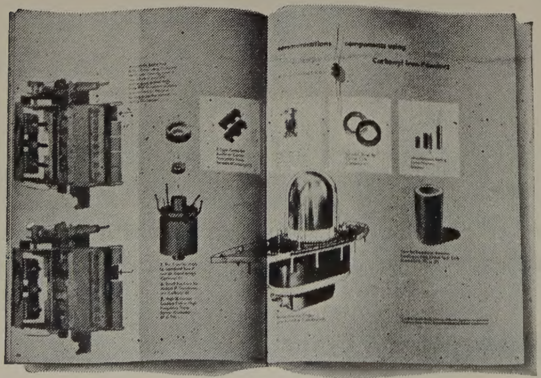

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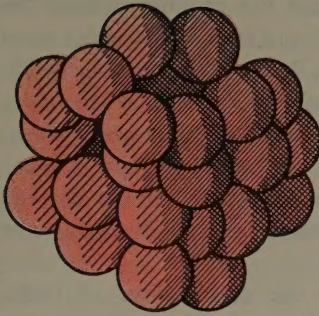
The Relation Between Energy and Mass

FREDERICK SEITZ, JR.



ONE of the extremely important corollaries of the theory of relativity promulgated by Einstein in 1905 is the principle that all forms of energy possess inertia, which most commonly is associated with matter. Thus a body that contains heat energy should have somewhat more mass than an otherwise identical but colder body. Similarly, a hollow box with perfectly reflecting internal walls has more mass if radiant energy is streaming back and forth within these walls than if the radiation is absent. According to the theory, the relationship between the components of mass M and the energy E is

$$M=\frac{E}{c^2}$$

or

$$E=Mc^2 \qquad (1)$$

in which c is the velocity of light, or 3×10^{10} centimeters per second in the centimeter-gram-second system of units. In this system, M is in grams and E in ergs.

The atomic bomb, among other things, catapulted Einstein's mass–energy relationship into the engineers' world. In addition to the accustomed heat reactions of chemistry, there now is possible the release of a million times greater amount of heat from reactions involving the atom nucleus. This is the second in a series of articles developed by the AIEE nucleonics committee.

One reasonably may ask why the velocity of light should enter into this fundamental equation. The simplest answer to this question is that the velocity of light is a very basic quantity in the theory of relativity and hence enters into many of the equations derived from it. It is notable, for example, that the velocity of light is the same for all observers, regardless of how fast they are moving relative to one another, that is, it is a basic constant. Moreover, this velocity is the fastest that any form of energy can be propagated.

When Einstein gave the world this mass–energy formula, it seemed likely that the relation was only of philosophical interest and always might remain so. This was because the mass represented by all ordinary amounts of energy conversions is so infinitesimally small compared with the mass of the materials involved in the generation or storing of this energy. This expectation has been altered, however, by the development of laboratory-controlled nuclear reactions in which elements are transmuted, for the changes in mass that occur in these reactions turn out to be comparable to the masses of the elements involved. More specifically, the atomic bomb abruptly changed engineers' view of the Einstein relation.

THE MASS CHANGES IN ORDINARY CHEMICAL AND PHYSICAL PROCESSES

Consider the changes in mass that occur in the course of ordinary chemical reactions. A typical reaction of common interest is that between hydrogen and oxygen to produce water. When 18 grams of water (about two-thirds ounce; an amount equal to the molecular weight of water and referred to as one mol) are produced by the reaction of hydrogen and oxygen, 2.4×10^{12} ergs (67 watt-hours) of heat energy appear. Although this is an appreciable amount of heat, it represents the disappearance of an almost undetectable but calculable amount of mass.* The loss of mass associated with the formation of each gram of water is $1^1/_2\times10^{-12}$ grams. That much has been converted to energy—an exceedingly small proportion!

The more common heat-producing reaction is the burning of coal. One ton of carbon combined with oxygen produces 28 million Btu or 8,200 kilowatt-hours of energy. Here, too, the mass disappearance is infinitesimal, 12 millionths of an ounce or one 10 billionth of the total.

Before comparing this change in mass with measurable changes, we may consider another typical problem. When one mol of graphite (12 grams, or nearly one-half ounce) is heated from room temperature to 7,500 degrees Fahrenheit, approximately 100 Btu are absorbed in the form of heat. The absorption of this energy results

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* The mass loss when hydrogen and oxygen are combined to form one mol (18 grams) of steam is

$$M=\frac{E}{c^2}=\frac{2.4\times10^{10}}{9\times10^{20}}=2.7\times10^{-11}\text{ grams}$$

The mass per gram of steam is

$$M=\frac{2.7\times10^{-11}}{18}=1.5\times10^{-12}$$

Essentially full text of "The Relation Between Energy and Mass," which appeared in *Westinghouse Engineer*, March 1946.

Frederick Seitz, Jr. is head of the department of physics at the Carnegie Institute of Technology, Pittsburgh, Pa.

in a fractional increase in the mass of the graphite that is closely comparable to that lost by hydrogen and oxygen in the reaction just discussed.

These mass changes and all other in the familiar heat reactions are so insignificant that, although predicted by Einstein, they have been considered of no engineering importance. They are indeed beyond measurement.

The most sensitive instrument for measuring changes in mass by direct means is the mass spectrograph,[1] which is used to determine the weights of both atoms and molecules. Although the most highly refined mass spectrographs have made it possible to determine differences in the mass of the lightest elements to several parts in one million, even this sensitivity is, unfortunately, about one million times too coarse to detect the changes in mass that occur when hydrogen and oxygen combine to form water. Similarly we must conclude that the changes in mass that occur when ordinary bodies are heated to temperatures attainable even in the laboratory at present are at least a million times too small to detect by any means now available.

THE ENERGY ASSOCIATED WITH ORDINARY MASSES

The fact that the changes in mass associated with ordinary reactions are so exceedingly small compared with the masses used to release the energy shows that the latent energies associated with ordinary masses are enormous. It follows at once from the fundamental mass–energy equation† that the energy associated with one ounce of matter—any matter—is about 707×10^6 kilowatt-hours, or equivalent to the yearly output of an 80,000-kw power station at 100 per cent load factor. This is equal to the energy released in the chemical formation of about 211,000 tons of water from hydrogen and oxygen.

Although this observation is astonishing, it is, unfortunately, not very useful unless we have at hand a mechanism whereby the energy resident in matter may be released, either in part or in full. This, in a sense, is the real problem of modern physics, and is one on which substantial progress has been made in the last 15 years, dramatically demonstrated in New Mexico and in Japan.

NUCLEAR REACTIONS AND MASS CHANGES

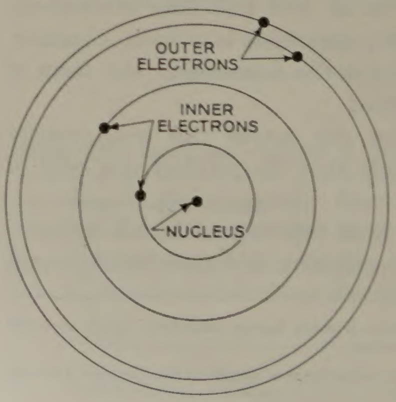
All atoms are composed of negatively charged electrons revolving, in more or less planetary fashion at various radii, about a central positively charged nucleus which contains almost all of the mass of the atom, Figure 1. The coulomb field of the nucleus prescribes the nature of the electronic orbits. The charge on the nucleus is always an integer multiple of the charge of the electron, with reversed sign. This integer, called the atomic number (designated by P), is the number of planetary electrons in the atom when it is in its normal, uncharged state. Likewise it is the number of protons in the normal nucleus. Thus the atomic number for hydrogen is 1, for carbon 16, and for uranium, the most massive of nature's elements, the atomic number is 92.

The chemical properties of atoms are determined by the properties of the outermost planetary electrons. When atoms are combined in ordinary chemical reactions, it is the motion of these electrons that is altered; the nucleuses and the innermost orbital electrons are not affected appreciably.

All power derived from the combustion of fuels, ordinary explosions, and other chemical processes—even muscle power—utilizes the energy liberated when atoms exchange or share between themselves the electrons that form the outer portion of an atom's structure. Indeed, only those electrons farthest away from the nucleus of an atom are involved in ordinary chemical reactions, and even in the most energetic of them, the nucleus is not disturbed. Thus, a carbon atom retains its identity when it is taken through a complicated series of organic reactions, or when it is converted to carbon dioxide in the combustion of a fuel.

Since 1932, when the neutron was discovered, all nucleuses are known to be composed of protons and neutrons, which are bound together by forces of mutual attraction. The proton, which appears in isolated form in the nucleus of ordinary hydrogen, has a positive charge equal to the negative charge of the electron, but is 1,840 times heavier. The absolute mass of the proton is 1.673×10^{-24} gram; its mass is 1.0076 on the relative scale for which the mass of oxygen is set arbitrarily at 16.000. The neutron, which is not found free in nature and which can be made free only for short periods of time, has no charge and possesses a mass slightly larger than that of the proton. This mass is 1.0089. The integer that gives the number of neutrons

Figure 1. A schematic representation of the atom



The electrons move in orbits about the positively charged central nucleus. Only the outermost electrons are influenced appreciably by chemical binding. The diameter of the orbits of these electrons is of the order of 5×10^{-8} centimeter in most atoms. The nucleus is about 100,000 times smaller, but contains almost all of the mass of the atom

---

† The energy associated with a given amount of mass is

$$M=\frac{E}{c^2}$$

$$E=M\times c^2$$

$$E \text{ per gram}=1\times9\times10^{20} \text{ ergs}$$
$$E \text{ per ounce}=28.35\times(9\times10^{20})\times(2.78\times10^{-14})$$
$$=707\times10^6 \text{ kilowatt-hours}$$

in a given nucleus commonly is designated by N. Similarly the sum of the neutrons and protons, $N+P$, gives the total number of particles in the nucleus and is commonly called the mass number, A.

Inasmuch as the charge on the nucleus is determined by the number of protons and because this charge determines the number and behavior of the orbital electrons, all atoms having the same number of protons belong to the same chemical species, regardless of the number of neutrons the nucleus may contain. In fact, many elements possess mixtures of atoms, or isotopes, in which the number of neutrons in the nucleuses differ. All isotopes of an element are chemically identical (hence inseparable by ordinary chemical means) and differ in mass number only by the differences in the neutrons in their nucleuses. For example, two types of hydrogen atoms are stable. In one of these the nucleus is composed of a single proton; in the other it is composed of a proton and a neutron in combination. The latter type of hydrogen atom (heavy hydrogen) is relatively rare, being present to only about one part in 5,000 in natural hydrogen.

It is customary to designate the element of given P and A with the symbol ${}_P\mathrm{Ch}^A$, where Ch is the chemical symbol. For example, ordinary hydrogen is designated as ${}_1\mathrm{H}^1$, whereas the hydrogen containing a neutron is designated ${}_1\mathrm{H}^2$ because A is equal to two for it. Similarly, the most abundant isotopes of helium and oxygen are designated by the symbols ${}_2\mathrm{He}^4$ and ${}_8\mathrm{O}^{16}$, respectively. In this terminology the neutron receives the symbol ${}_0n^1$ because its charge is 0 and its mass number is 1.

If the forces between neutrons and protons when combined to form a nucleus were very small, in the sense that the energies of combination were comparable to those of the atoms in ordinary chemical reactions, the mass of a nucleus containing P protons and N neutrons, for all practical purposes, would be equal to the total mass of the constituent particles. We then might write:

$$M(P, N) = 1.0076P + 1.0089N \tag{2}$$

This rule would be the counterpart of the rule of ordinary chemistry that states that the mass of a compound is equal to the mass of its constituent atoms, and which, as discussed, is valid only as an approximation. The mass deficit or excess in an equation of a chemical heat reaction is neglected because it is insignificant. For a nuclear equation to balance, one side must contain, in addition to the masses, one factor significant of the energy involved. Thus, equation 2 must be written:

$$M(P, N) = 1.0076P + 1.0089N - E \tag{3}$$

where E is the binding energy in mass units.

Actually the energies of interaction of the nuclear particles are so great that the changes in mass that occur are well within the accuracy of observation of good mass spectrometers. Consider, for example, the reaction between two neutrons and two protons to form helium. The mass of the two neutrons is 2.0178 and of the protons, 2.0152, or 4.0330 total. When combined to form a helium nucleus, however, their mass is 4.0028. Hence there is a decrease of 0.0302 unit of mass when helium is formed of the elementary particles. This represents nearly one per cent of the mass of the helium atom. In more commonplace terminology, it represents an energy release of nearly five million kilowatt-hours per ounce (17 billion Btu) of helium produced. This energy evolved could appear in many forms, for example, as X rays or in the form of kinetic energy.

Clearly then the masses of nucleuses differ appreciably from the aggregate mass of the free constituent particles. Mass can be said to be conserved in such reactions, even in a practical sense, only if the mass associated with the energy evolved is taken into account.

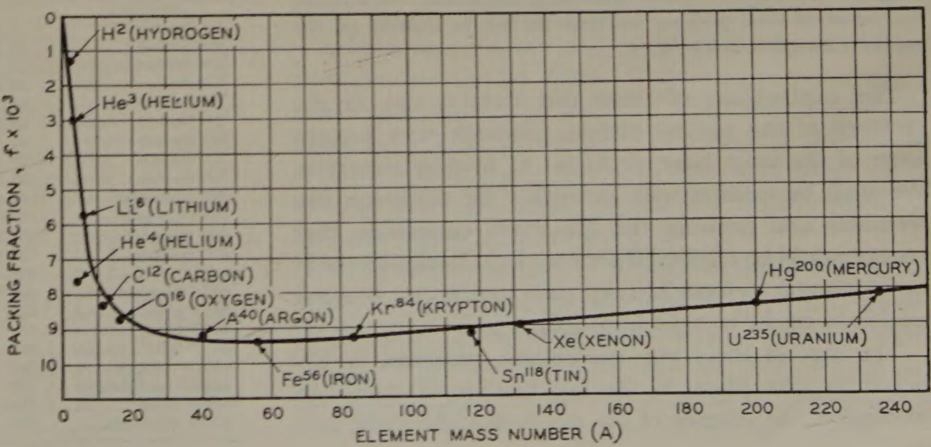
For example, in the nuclear reaction by which helium is formed from hydrogen:

$$2N + 2P = {}_2\mathrm{He}^4 - 0.0302$$

The fact that nuclear reactions involve appreciable changes in mass suggests that changes in mass are a convenient way of determining the energy of these

Figure 2. The variation of the packing fraction with mass number

The values are plotted in a negative direction for clarity. The units used in the vertical axis are 10^{-2} relative mass units in the scale for which the mass of oxygen is 16. It will be seen that maximum stability occurs in the vicinity of iron, and that both the very light and the very heavy elements are less stable than those of intermediate mass. He⁴ *lies appreciably below the curve, showing that helium is unusually stable for a light atom*



reactions. For example, the difference between the mass of an atom and the mass of its components separately provides a measure of the energy of cohesion of a given nucleus, or the energy required to break the nucleus into isolated component particles. This difference commonly is called the mass defect, or binding energy.

The physicist has found it appropriate to employ as a unit of energy the electron volt. When a particle having the charge of one electron falls through an electric potential of one volt, it gains a kinetic energy of one electron volt. This unit of energy is used widely as a measure of the energy of individual atoms or molecules. Thus most chemical reactions involve an energy change of the order of one electron volt per molecule.

A list of the mass defects of common elements is given in Table I. It should be reiterated that these are the energies released when nucleuses are formed from free neutrons and protons. It readily is seen that the numbers are about a million times larger than the heats of reaction of chemical systems.

It is interesting to consider another quantity that is related closely to the mass defect. This quantity, which is called the packing fraction *f*, is equal to the mass defect *D* divided by the number of particles in the nucleus *A*. The packing fraction provides a measure of the binding energy of a nucleus per particle involved. The larger the packing fraction, the greater the stability of the average particle in the nucleus. Table I contains values of the packing fraction for the elements listed, whereas Figure 2 shows the packing fraction in graphical form. For purposes of visualization, the values of the packing fraction are plotted in the figure in the negative direction. Thus the most stable elements appear near a minimum of the curve, instead of near a maximum. The packing fraction curve discloses interesting facts:

1. The stability increases very rapidly in going from the lightest element (hydrogen) to approximately the middle weight elements, just beyond iron, and then gradually decreases again. It follows that the light elements and the heavy elements are less stable than those of intermediate mass, such as zinc and copper.
2. Some of the lighter elements, most notably helium and oxygen, are much more stable than their neighbors. As a result, the values of their packing fractions do not lie exactly on the smooth curve, but below it.

The explanation of these two facts is not in the province of the present article, although they present some of the most basic problems of nuclear structure. We shall be content with accepting the empirical observation and drawing the important conclusion that energy would be released if the very light nucleuses could be combined to form heavier ones and if the heaviest nucleuses could be split into lighter ones.

The first of these two exothermic processes is believed to take place in the hot interior of stars. In particular, the interior of the sun is thought to be at a temperature of about 20×10⁶ degrees and that at this temperature the following sequence of reactions is taking place spontaneously:

$$\left.\begin{array}{l} {}_6C^{12}+{}_1H_1\rightarrow{}_6C^{13}+e^+ \\ {}_6C^{13}+{}_1H^1\rightarrow{}_7N^{14} \\ {}_7N^{14}+{}_1H^1\rightarrow{}_7N^{15}+e^+ \\ {}_7N^{15}+{}_1H^1\rightarrow{}_6C^{12}+{}_2He^4 \end{array}\right\} \qquad (4)$$

in which e^+ is a positive electron or positron. Each reaction in this series has been studied under laboratory conditions with the use of protons accelerated to high rates of speed with man-made devices. Each reaction is known to be exothermic. In the first and third reactions positrons are emitted. The sum total of the four reactions is equivalent to the single reaction:

$$4{}_1H^1\rightarrow{}_2He^4+2e^+$$

as simple addition of both sides of the four equations shows. Thus, carbon merely plays the role of a catalyst and the basic reaction is that of forming helium from hydrogen. Other reactions releasing enormous quantities of heat are likely.

The release of energy by the degradation of the heavier elements into lighter ones is accomplished in the fission of uranium ${}_{92}U^{235}$ and plutonium ${}_{94}Pu^{239}$. Both of these isotopes are made unstable when a neutron is added to their structure; as a result they proceed to split into two nearly equal fragments. The energy released in this splitting process is 200 million electron volts per atom, or 650,000 kilowatt-hours per ounce.

THE COMPLETE CONVERSION OF MATTER INTO ENERGY

In all reactions mentioned only a fraction of the matter present is transformed into available energy.

Table I. The Mass Defects and the Packing Fractions of Important Elements

	Mass Defects			
	Mass Units $\times 10^{-3}$	Kg-Cal/Mole $\times 10^7$	Electron Volts Per Atom $\times 10^6$	Packing Fraction, Mass Units $\times 10^{-3}$
${}_1H^2$ (hydrogen)	2.35	5.05	2.19	1.17
${}_2He^4$ (helium)	30.29	65.00	28.20	7.57
${}_3Li^6$ (lithium)	34.31	71.31	31.94	5.72
${}_3Li^7$ (lithium)	42.01	90.14	39.11	6.00
${}_4Be^9$ (beryllium)	62.3	133.7	58.0	6.92
${}_5B^{10}$ (boron)	69.2	148.4	64.4	6.92
${}_5B^{11}$ (boron)	81.4	174.7	75.8	7.40
${}_6C^{12}$ (carbon)	98.6	211.6	91.8	8.22
${}_6C^{13}$ (carbon)	103.8	222.9	96.7	7.98
${}_7N^{14}$ (nitrogen)	112.0	240.4	104.3	8.01
${}_7N^{15}$ (nitrogen)	123.5	265.1	115.0	8.20
${}_8O^{16}$ (oxygen)	136.6	293.2	127.2	8.53
${}_8O^{17}$ (oxygen)	141.1	302.6	131.3	8.30
${}_{18}A^{40}$ (argon)	368	788	342	9.20
${}_{22}Ti^{48}$ (titanium)	446	957	415	9.30
${}_{26}Fe^{56}$ (iron)	523	1,123	487	9.35
${}_{36}Kr^{84}$ (krypton)	783	1,680	729	9.30
${}_{50}Sn^{118}$ (tin)	1,080	2,330	1,011	9.15
${}_{54}Xe^{132}$ (xenon)	1,190	2,559	1,110	9.00
${}_{64}Gd^{158}$ (gadolinium)	1,390	2,745	1,290	8.80
${}_{82}Pb^{204}$ (lead)	1,700	3,641	1,580	8.35
${}_{92}U^{238}$ (uranium)	1,900	4,103	1,780	8.00

In the case of the transformation of hydrogen into helium this is nearly one per cent, but the conversion is still not complete. In fact, both in this reaction and in the fission of uranium and plutonium the total number of protons and neutrons is not altered so that the number of material particles is not changed. They simply are rearranged into a more stable form. The bonus derived as heat is related to the difference in stability between the original and the end substances. Or looking at the problem in a different way, the mass of the final substances is slightly less than that of the original substances.

Can we expect to convert material particles completely into energy? In the first and third of the hydrogen-to-helium reactions an electron having a positive charge is produced. These positive electrons, which have the same mass as an ordinary negative electron, exist only briefly. As soon as they have an opportunity to collide with a negative electron they combine with it and produce X rays, which are just light waves having a very short wave length. In this process, two material particles—a positron and an electron—combine to produce radiant energy. Their mass disappears entirely. It can be said without ambiguity that in this instance the conversion of ponderable matter to energy is complete.

The reverse process also has been observed. In fact, positive electrons first were discovered in this way. The hardest X rays (that is, shortest wave length) produced in an X-ray tube operating at more than one million volts produce pairs of electrons of opposite sign when they pass close to nucleuses.[2] The threshold energy of the X rays is just the value needed to generate the mass of the two electrons, one positive and the other negative. Any energy the X rays possess above this threshold value is converted into the kinetic energy of motion of the electrons. The positive and negative electrons thus formed are, as pointed out, short-lived. They recombine, their mass disappearing in favor of radiant energy, this time of longer wave length than initiated the process.

Table II. Conversion Table For Energy Units

Multiply	By	To Obtain
Million electron volts	1.07×10^{-3}	Mass units
	1.60×10^{-6}	Ergs
	$3.83\times10^{\ 14}$	Gram-cal
	4.45×10^{-20}	Kw-hr
Mass units	9.31×10^{2}	Million electron volts
	1.49×10^{-3}	Ergs
	3.56×10^{-11}	G-cal
	4.15×10^{-17}	Kw-hr
Ergs	6.71×10^{2}	Mass units
	6.24×10^{5}	Million electron volts
	2.39×10^{-8}	G-cal
	2.78×10^{-14}	Kw-hr
G-cal	2.81×10^{10}	Mass units
	2.62×10^{12}	Million electron volts
	4.18×10^{7}	Ergs
	1.16×10^{-6}	Kw-hr
Kw-hr	2.41×10^{16}	Mass units
	2.25×10^{19}	Million electron volt
	3.60×10^{13}	Ergs
	8.60×10^{5}	G-cal

It is not too much to expect that other material particles can be generated and annihilated in a similar fashion and that these processes will be observed in the near future. From the standpoint of the fundamental mass–energy relation we can state with assurance that protons and neutrons, the fundamental bricks of ordinary matter, will not be generated until units of energy of the order of one billion electron volts are available for the conversion, because this is the energy associated with the mass of either of these particles. Thus, before X rays could be used to generate neutrons or protons, it would be necessary to obtain rays of the hardness that would be produced in a tube that operates at one billion volts or more, which is ten times larger than the highest voltages attained thus far. Some cosmic rays have more than this amount of energy available for inducing reactions. Possibly the first generation of protons and neutrons will be observed by studying the reactions induced by cosmic rays.

Man-made transformations of this type will occur in laboratories only when machines have been devised that can supply charged particles with kinetic energies of the order of one billion electron volts. This probably will come within the next decade. Einstein's astounding prediction 40 years ago of the interchangeability of mass and energy has assumed engineering significance. The principles of nuclear physics must be added to the engineer's handbook of fundamentals.

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Absorption-Emission Pyrometer

A new instrument, the Absorption-Emission Pyrometer, for measuring high flame temperatures such as those encountered in rocket exhaust flames, has been described before the Optical Society of America by D. H. Jacobs, of North American Aviation, Inc.

A light source in the instrument sends a beam of light through the exhaust flame of the rocket and another beam from the same source is by-passed around the flame by a series of mirrors. A system of mechanical shutters causes these beams to fall alternately on a photoelectric cell which is connected to various monitoring, amplifying, and recording circuits.

Studies of the theory of this device show that if the brightness of the source is varied so that the photoelectric cell always receives the same amount of light from the beam that passes through the flame and the one that passes around it, the temperature of the flame will bear a known relation to that of the light source.

Calculating Machines

ROBERT C. TUMBLESON

The automatic electronic computer is the result of years of evolution in the field of calculating machines. At present the field is developing so rapidly that a machine may become obsolete between the time it is designed and the date of its completion. Applications for high-speed calculators are increasing rapidly as the characteristics of the machines become more well known.

MEMORY is an indispensable tool in research and the organization of ideas. Frequently we are amused by the endless amounts of paper work produced by professors and engineers. But, in reality, their notes and memoranda, reference books, and tables are adjuncts to memory. They represent storehouses of facts upon which the researcher can draw when he needs them.

Memory also is the key to the design and operation of the mammoth, automatic, high-speed calculating machines developed during and since World War II. These machines must remember the sequence of operations, which may involve thousands—even millions—of additions, subtractions, multiplications, or divisions. They also must store answers found during computation and reintroduce them at the proper point and proper time. They should be able to sense an error in computation and stop so that corrections can be made. Finally, the machines must know when they have the answer; otherwise they might continue to run forever.

The use of electronic circuits in the newer machines permits calculations to be made with inconceivable swiftness. Up to 5,000 10-digit numbers may be added in one second. In a full 8-hour day one such machine can multiply nearly 10,000,000 pairs of such numbers. Since mathematicians can break down any mathematical problem into the fundamental operations of addition and multiplication, these fantastic speeds may be utilized in the solution of problems that engineers and scientists have not even dared think about before, let alone attempt to solve.

During World War II, the Army and Navy—particularly the Army Ordnance Research and Development Service—encouraged development of supermachines for calculating ballistics tables and solving engineering problems in the design of ships, radar equipment, and atomic energy facilities. To date, the development of calculating machines has depended almost entirely upon the military services and certain civilian government agencies, such as the Census Bureau, Bureau of Standards, and the National Advisory Committee for Aeronautics. Since development costs have been added to construction costs of machines now built or in construction, the cost of each unit has been high—from $300,000 to $500,000 or more. Subsequent models will be much cheaper, perhaps $50,000 or less, an insignificant price considering that electronic machines will perform the computations demanded in many business and industrial problems using only a two-hundredth of the man-hours required by the best present methods.

COMMERCIAL APPLICATIONS

Insurance companies will use them for calculating dividend and mortality rates and actuarial tables. Such machines vastly will simplify accounting and billing for public utilities and mail order houses. They will permit large-scale expansion in the use of public opinion polls, marketing surveys, and other statistical sampling techniques. Simultaneous equations in dozens of unknowns can be solved. This will revolutionize methods in such diverse fields as weather forecasting, economics, and psychological and medical research.

A tax expert, for example, will be able to estimate the effect of a sales tax in producing revenue, upon production and sales of the commodity taxed, and upon the economy at large.

Map makers and surveyors encounter routine problems in adjustment of data which involve the solutions of as many as 400 equations in as many unknowns. By hand machine methods such problems are almost impossible to solve.

Meteorologists can set up the partial differential equations whose solutions describe the weather, but at present their solution is prohibitively time-consuming. The weather is here and gone weeks before the calculations can be made by ordinary methods. Electronic machines will provide the information in a matter of hours.

These machines will solve the equations of aerodynamics and hydrodynamics under the most complex conditions. Airplane designers will be able to plot in advance the flow around a new airfoil, at and beyond the speed of sound. Such calculations will supplement or even may eliminate the need for costly wind tunnel experiments.

Radio engineers can solve wave guide equations, problems in antenna design, and determine the electromagnetic fields in the neighborhood of oddly shaped

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conductors. Construction engineers will obtain predetermined stress and strain patterns for beams and bridges. Important functions in pure and applied mathematics will be tabulated and published on punch cards, magnetic tape, or photographic film.

1,800 VERSUS 36½

Consider an example. Each month busy American exporters file more than 400,000 declarations with United States customs officials, covering over a half million individual shipments abroad. From these declarations the Census Bureau prepares its monthly tabulation of exports. It is no inconsiderable job.

There are approximately 3,500 commodities, 150 countries of destination, and 49 customs districts, or a total of more than 25 million possible combinations. Although in any one month most of these categories are blank, there will remain about 60,000 entries on the summary table.

Table I. Estimated Man-Hours Required for Census Tabulation by Present Methods and With Proposed Electronic Machine

Problem	Man-Hours Required	
	Present Methods, Hours	Electronic Methods, Hours
Sorting 550,000 items over 12-column code	500	32
Editing ("pricing") 550,000 detail items	1,000	2
Tabulation of 60,000 summary totals	200	2
Processing and tabulating tables	100	½
Total	1,800	36½

Punch cards are prepared showing quantity shipped and value of the 550,000 shipments. The first operation sorts these by commodity, country, and district code. Next a listing is made of all cards, and skilled editors check the list for disparity between quantity and value. The cards then are tabulated and 60,000 summary cards prepared for each of the entries on the summary table. Finally, the summary cards are processed and tabulated in various ways in order to prepare the published tables.

At the present time the National Bureau of Standards is supervising design and construction of two high-speed electronic calculators, one of which will be installed by the Census Bureau. Table I shows the estimated saving in man-hours by using the new electronic machine as compared with present equipment.

HOW THEY GREW

The first mechanical tabulating machine, forerunner of the desk machines now in common use, was designed and built in 1642 by Blaise Pascal, the great French mathematician and philosopher. Even today such machines cannot remember more than one instruction. They must be reinstructed before they can perform the next addition, subtraction, multiplication, or division.

For many problems, this is not enough. For example, take a problem which is solved by making closer and closer approximations to the solution. A first rough approximation is obtained from a predetermined cycle of mathematical operations. This rough answer then is substituted back into the equation and the cycle repeated. A new and better approximation results. This happens again and again until the answer is correct to the required number of decimal places.

A machine capable of handling such problems must remember the sequence of operations to be followed. It also must be capable of storing intermediate numbers and reintroducing them into the computation at the proper time. The problem of memory, then, is basic in constructing fully automatic calculating machines.

In 1834 an English actuary, Charles Babbage, saw the need for automatic computing machines, and designed a so-called analytical engine to do whole series of operation without the intervention of an operator. His machine consisted of two parts—a storage space for numbers and a "mill," the actual calculating mechanism. The sequence of operations was determined by means of Jacquard cards, similar to the punch cards used by Jacquard weavers to control looms in the production of patterned cloth. Although Babbage was unable to obtain sufficient financial support to finish his full-scale machine, his design was feasible and a model actually worked.

In 1937 at Harvard University, Doctor Howard H. Aiken and the International Business Machines Corporation began work on the first of the modern machines. When completed in 1944, this completely automatic, sequenced, general purpose, digital computing machine was taken over by the Navy Department for war research problems.

The term "automatically sequenced" indicates that the machine performs a series or sequence of different operations without attention from an operator. The term "digital" indicates that the machine deals with ordinary numbers or digits which it manipulates almost exactly like human arithmeticians. Machines such as the slide rule translate numbers into some physical quantity such as length, rotation of a shaft, or a voltage. The computation is done in accord with physical laws and the answer must be translated back into figures. These are called "analogue" machines.

The Aiken machine automatically sets up its program for a given problem from a code punched into a paper tape. The code may say, for example: "Take the number out of unit *A*; deliver it to unit *B*; start operation *C*."

The machine keeps on hand certain frequently used constants, such as a table of logarithms and trigonometric functions. Three units are available to read off other tabulated functions from a paper tape. These units are also able to interpolate or to determine intermediate values of the functions which fall between the numbers actually carried on the tape. In addition, before the calculation starts, up to 60 24-digit constants may be stored on a special "constant register." Any of these numbers may be put into the calculating units whenever desired.

The machine has a total of 72 adding registers or units and a central multiplying and dividing unit. In these the actual arithmetical operations are done by means of electromechanical, rotating, wheel-type counters. The results either may be punched on cards or printed on an automatic typewriter.

The main limitation of the speed of operation is the time required for putting numbers into the machine from the punch cards. This normally takes about six-tenths second. Once in the machine, actual addition of two numbers takes three-tenths second, while multiplication of two 10-digit numbers takes from 3 to 5 seconds.

Shortly after the first Aiken machine was completed, two 5-digit computers of different design were installed at the Naval Research Laboratory, Bellevue, Md., and at Fort Bliss, Tex., for the Army Ground Forces. These were built at the Bell Telephone Laboratories, under the direction of Doctor George Stibitz and S. B. Williams. Wheel-type counters were not used, but each digital position was represented by a combination of a 2-position telephone-type electric relay and a 5-position relay, which increased the calculating speed.

Two 8-digit machines of similar design currently are being built for the Ballistic Research Laboratory, Aberdeen, Md., and for the Langley Memorial Laboratory of the National Advisory Committee for Aeronautics, Langley Field, Va.

Two 6-digit relay machines also have been built on an experimental basis by the International Business Machines Corporation for the Ballistic Research Laboratory, and the Naval Proving Ground, Dahlgren, Va. Scheduling of a sequence of up to 96 operations is possible by means of a plugboard.

Doctor Aiken also is building a relay-type 10-digit machine for the Dahlgren Proving Ground. Forty-six relays are required for each 10-digit number and a total of 100 numbers or 1,000 digits can be stored. Numerical data and the sequence control are put into the machine on standard teletype tape.

ENIAC

In the fall of 1945 the first electronic computing machine began operation. At that moment electromechanical and relay calculators became outmoded. Henceforth, high-speed calculating machines would be designed to operate electronically.

The original electronic machine, the electronic numerical integrator and calculator (ENIAC), was built for the Ballistic Research Laboratory by the Moore school of electrical engineering of the University of Pennsylvania, Philadelphia, Pa.

The internal mechanism of the ENIAC is entirely electronic, which accounts for its enormous operating speed. The relay-type counter represented a marked advance in speed over the revolving wheel counters used in standard desk calculators and punch card equipment. Yet the maximum speed with which a relay can change from one state to another is from 1/200 to 2/200 second, while that of a vacuum tube is of the order of 1/1,000,000 second or less. The ENIAC can calculate the trajectory of a shell in considerably less time than the shell takes to reach its target.

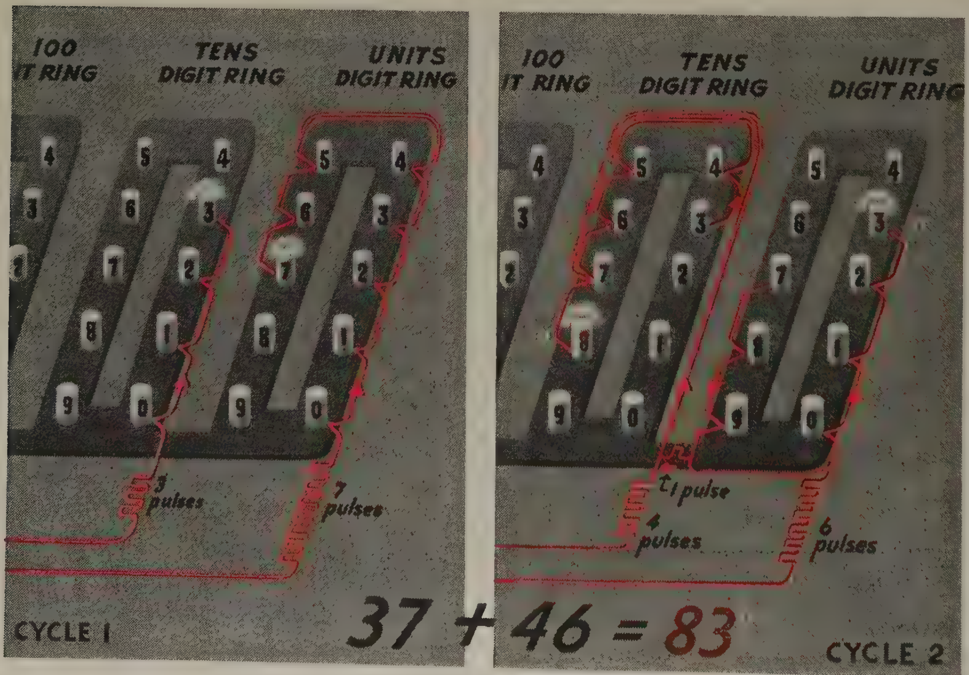


Figure 1. Each digit position on ENIAC counter has its own wire, so that pulses for all digits may be transmitted simultaneously

In advancing beyond the nine position on any ring a single extra pulse is transmitted to the adjacent ring on the left, representing carry-over

The basic counter in the ENIAC is essentially an electronic model of a wheel counter. It consists of a ring of 10 pairs of electronic tubes called flip-flops, each representing one of the digits from 0 to 9. Only one pair or flip-flop in any ring can be on at a time.

A number is introduced on the counter by means of a train of very short electric pulses. Each pulse advances the "on" flip-flop one position in the ring. The trains of pulses occur at intervals of 1/5,000 second. Each time the ring completes a cycle, the next ring to the left advances one position. Thus, in order to add 6 and 9, the initial train of 6 pulses advances the "on" flip-flop to the 6 position. The next train of 9 pulses, 1/5,000 of a second later, sends the "on" flip-flop to the 5 position, while on the adjacent ring the flip-flop moves to the 1 position.

As the ENIAC deals with 10-digit numbers, each unit must contain ten electronic rings or counters plus a positive or negative sign indicator. The digit pulses for a multidigit number are transmitted at the same time, so that each counter has its own inlet and outlet wire. All accumulator units are equipped with 5 inlet and 2 outlet trunk lines, each containing 11 wires for the 10 digits and sign. The multiple outlets provide complete flexibility in connecting the various units with each other.

A total of 20 10-digit accumulators is available, a multiplying unit, and a divider and square root unit. The maximum internal storage capacity or memory of the machine is 200 digits, although in addition three function tables are provided upon each of which up to 104 12-digit numbers can be stored before the computation starts.

Each unit of the machine is equipped with a program control, which is activated by a so-called central programming pulse. The central programming pulse is synchronized with the trains of digital pulses occurring every 1/5,000 second. By counting the central pro-

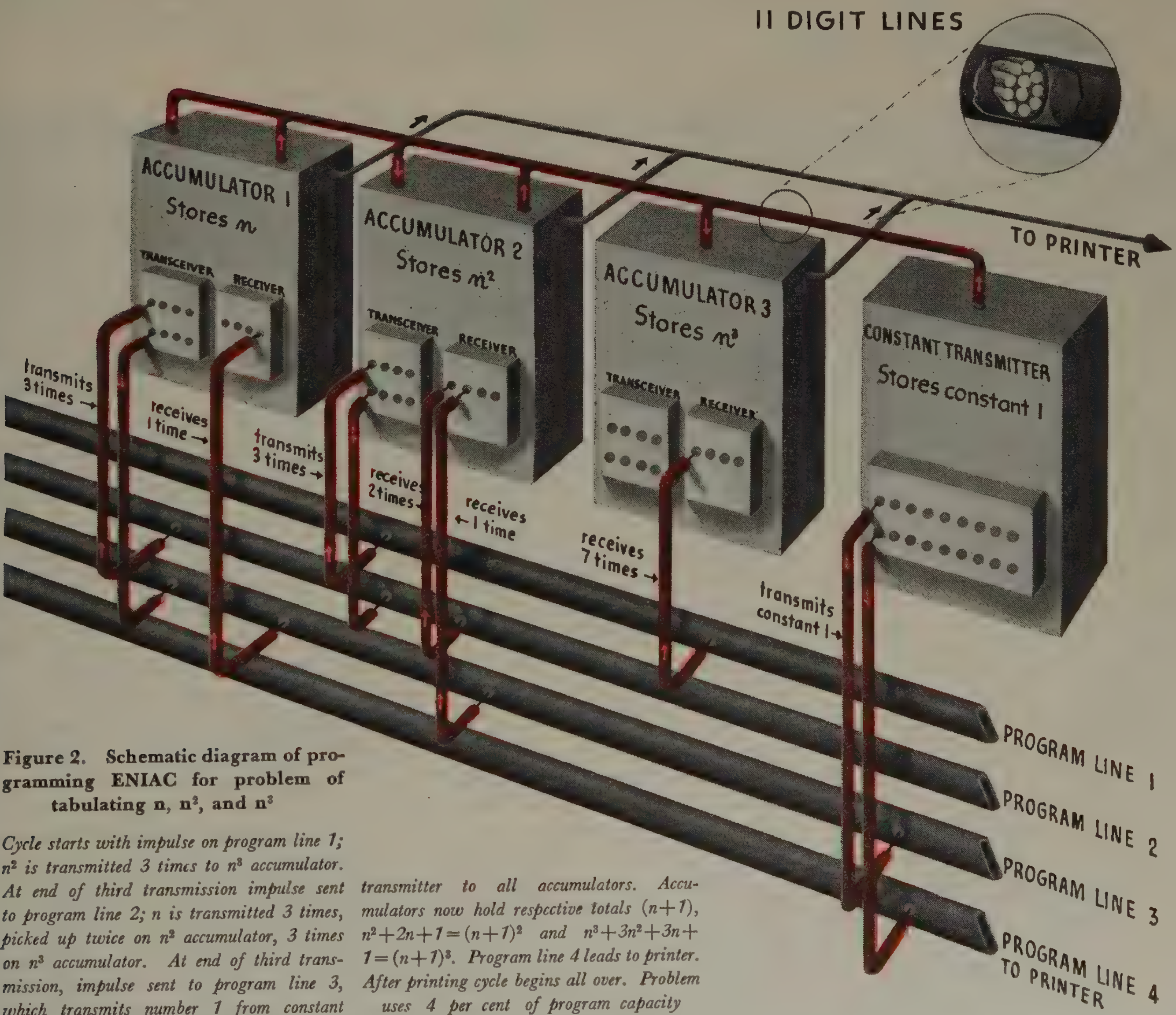


Figure 2. **Schematic diagram of programming ENIAC for problem of tabulating n, n^2, and n^3**

Cycle starts with impulse on program line 1; n^2 is transmitted 3 times to n^3 accumulator. At end of third transmission impulse sent to program line 2; n is transmitted 3 times, picked up twice on n^2 accumulator, 3 times on n^3 accumulator. At end of third transmission, impulse sent to program line 3, which transmits number 1 from constant transmitter to all accumulators. Accumulators now hold respective totals $(n+1)$, $n^2+2n+1=(n+1)^2$ and $n^3+3n^2+3n+1=(n+1)^3$. Program line 4 leads to printer. After printing cycle begins all over. Problem uses 4 per cent of program capacity gramming pulses the program control is able to follow the course of the computation and hence keep the machine on the proper sequence of operations.

ENIAC was built primarily for calculating firing tables. For this purpose the internal memory capacity was adequate. However, it also was used in solving partial differential equations arising out of research in nuclear physics. Frequently in such problems it is desirable during a calculation to retain more than the maximum of 20 numbers. When this occurs, the mathematician is hard pressed to program the flow of the problem through the machine so that it will run automatically without time-consuming halts and delays. Because of this inflexibility, programming of complicated problems requires considerable ingenuity and may take several weeks' study for even a high-powered mathematician.

Figures are read into the machine and taken off by means of punch cards. This also slows down the operation, because actual computing must stop until the reading or printing is completed. The full speed of which ENIAC is capable can be realized only after the numbers are in the machine.

The ENIAC occupies a room 30 by 50 feet and weighs 30 tons. It contains nearly 18,000 vacuum tubes. Several times a day check problems are run through the machine to determine that all tubes are functioning properly. Burned-out tubes usually can be located and replaced in 15 minutes. Under normal operating conditions, one tube must be replaced about every second day.

EDVAC

Now that the experts are aware not only of the capabilities of existing electronic calculating machines, but also of their weaknesses, they are prepared to build machines that far will surpass in performance anything heretofore dreamed of. The arithmetical mechanism of the ideal machine will be electronic to take advantage of the operating speed. The relatively slow punch card reading and printing apparatus will be replaced by a continuous data recording device, probably magnetic wire or photographic film. Finally, in order to obtain maximum flexibility in operation, an improved internal memory must be found for storing numbers that occur during involved computations. This memory apparatus should have greatly increased capacity. It should be integrated into the operation of the machine so that numbers can be put on or taken off any unit almost instantaneously. Furthermore, it is desirable to have the storage space far more compact than at present.

Recent research in radar and television leads to the conclusion that the memory element can be developed from ultrasonic or magnetic delay devices or perhaps iconoscope-like tubes of special design.

Here again federal agencies are in the forefront of the development. The Army Ordnance Department contracted with the University of Pennsylvania to build a better ENIAC, a machine called the electronic discrete variable calculator (EDVAC), to be completed this summer. [*Editor's note:* EDVAC now is scheduled for completion by January 1, 1948.] Ring counters no longer will be used for storage devices. Instead, an acoustical delay tank borrowed from radar will be used. In this system an electric impulse or signal is transformed into sound waves by means of a quartz crystal and introduced at one end of a 2-inch column of mercury. The signals pass down the column of mercury at the relatively slow speed of sound. At the other end they are changed back into an electric voltage, amplified, and returned to the starting point where the cycle is repeated. An endless parade of separate and distinct 10-digit numbers can be maintained on this device at one time. Numbers from the arithmetical units of EDVAC can be stored in the acoustical tank until it is time for them to be reintroduced into the calculation. Each delay line does the work of 550 electronic tubes in ENIAC. The actual arithmetic operations of EDVAC will be done in about one-third the time required for ENIAC, and programming a sequence of operations will be much simpler.

MANIAC

Another computing machine to which the Army Ordnance Department is contributing financial support is being built at the Institute of Advanced Study, Princeton, N. J., under the direction of Doctor John von Neumann and Doctor H. H. Goldstine.

The basic memory device of this machine will be a special purpose tube, somewhat like the television iconoscope. This tube, the selectron, was invented by Doctor Jan Rajchman at the laboratories of the Radio Corporation of America under the direction of Doctor V. K. Zworykin. A guided electron beam scans a multicelled plate of nonconducting material, each cell of which either may be charged or uncharged. Instead of a number system based on ten, the machine will use the binary system based on two and having only the integers one and zero.

The presence of a charge in a given cell on the nonconducting plate will indicate the integer one, absence of charge will indicate zero. A single tube will be able to retain up to 4,000 binary digits—equivalent to about 1,200 digits in the decimal system.

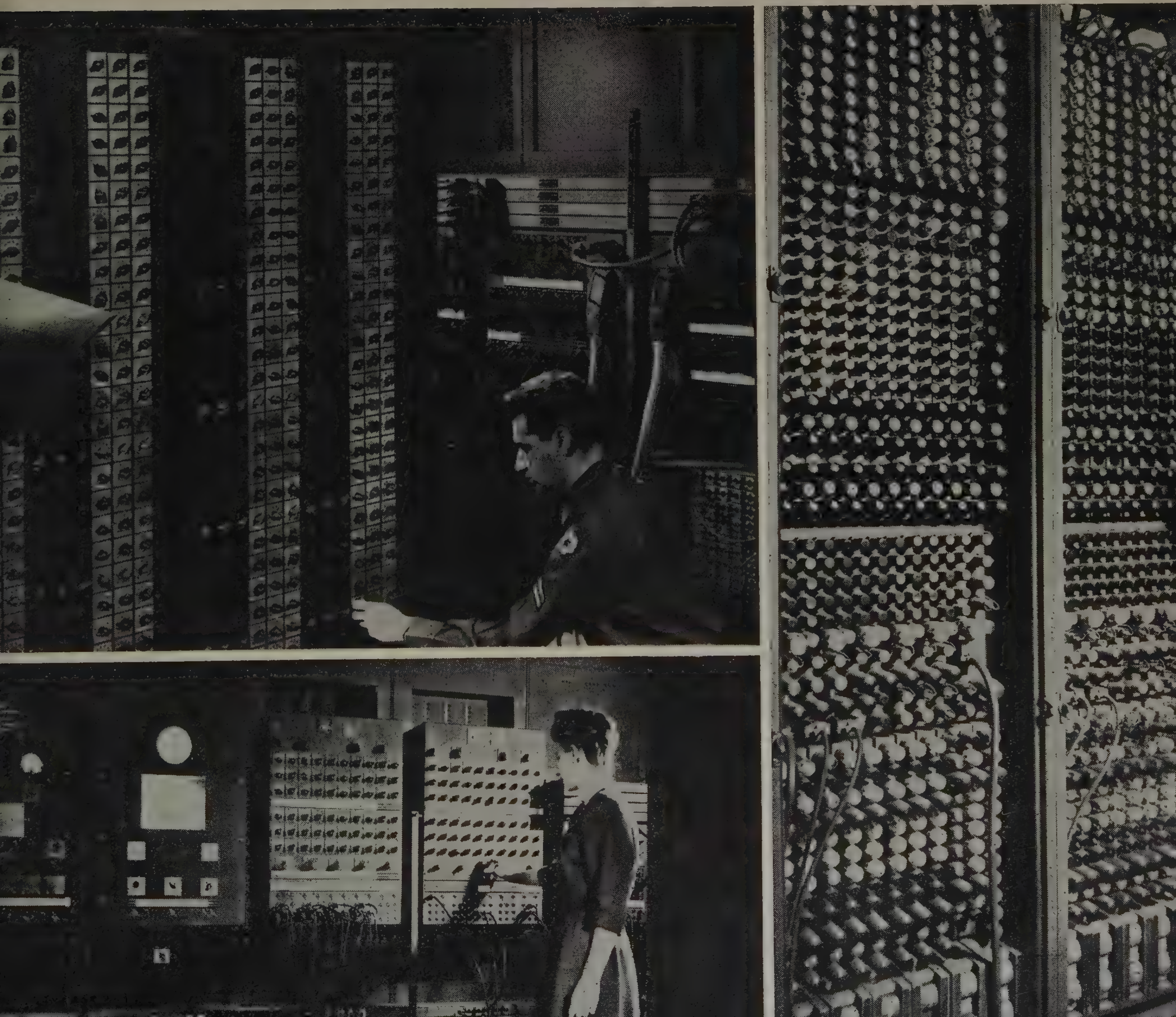
The controls on the machine will be extremely flexible. The machine will be able to distinguish between several possible courses of action and change the order of operations accordingly. For example, in the analysis of airfoil behavior at high speeds, a critical range is reached in the vicinity of the speed of sound. At speeds both above and below this range the change in behavior is regular. At the speed of sound a discontinuity occurs, characterized by the formation of shock waves and other phenomena. The controls can be set so that the machine automatically will sense when it enters such a region, and the calculations through the region will be made in far more detail than is ordinarily necessary.

UNIVAC

Perhaps the most ambitious program planned for new calculating machines is that under way at the Bureau of Standards, under the direction of Doctor J. H. Curtiss. The bureau has been asked to design and construct two electronic digital machines (universal automatic computers) of a general purpose type, one for the Bureau of the Census and one for the Office of Naval Research. In addition the bureau is engaged in an extensive research project financed by the Army Ordnance Department for fundamental studies of electronic components to be used in fire control and flight simulation devices. These are essentially high-speed input-output, memory, and other components, so that research in the two fields is supplementary. These studies are under the direction of Harry Diamond, chief of the Ordnance Development Division, Doctor J. W. Mauchly and J. P. Eckert, engineers on the ENIAC development, and Doctor von Neumann are project consultants.

Performance specifications drawn up for the bureau's machines call for speeds of computation substantially greater than that of ENIAC. Addition of two 10-digit numbers should take only 1/10,000 second; multiplication, 1/500 second; transfer from memory to computing unit, 1/10,000 second. The internal memory capacity must store at least 5,000 10-digit numbers, or a total of 50,000 digits. The input-output mechanism will be high speed, the input of a 10-digit number requiring 1/1,500 second and printing of results done at the rate of 12 characters per second. In addition the machines must be capable of random sorting of coded data, great flexibility in programming, and self-detection of errors.

Figure 3. Entering numbers on function table A of ENIAC (upper left). Switches are set manually, cannot be changed automatically during the problem. Five panels of ENIAC (lower left) are initiating unit, cycling unit, panels 1 and 2 of master programmer, and function table panel. The backs of two accumulators are shown (right). Tubes in upper left half are for counter circuits; those below in accumulator program controls



The machine for the Bureau of the Census should be completed during 1948, so that by the time of the 1950 census, it will have been in operation at least a year. Not only will its use facilitate the analysis of familiar population data, but it will permit far greater development of sampling techniques. This, in turn, will enable the bureau to obtain information in many fields heretofore untouched.

USE BY NAVY

According to present plans the Navy machine will be located in a large general-purpose computing laboratory, to be operated by the Bureau of Standards and staffed with personnel trained in methods of numerical analysis. Already the bureau has made plans for conducting basic research in applied mathematics. As the program develops it promises to make a lasting contribution to the scientific, commercial, and industrial resources of the United States.

These machines will take up about as much space as four or five ordinary size file cabinets. Despite their greater flexibility, they will operate with only 600 to 800 tubes, as compared with 18,000 for ENIAC. The external storage capacity for constants, tabulated functions, and other data, will be so compact that 35,000 or more digits can be stored per cubic inch.

FAR-REACHING SIGNIFICANCE

Over the long history of science, instruments and theory have advanced hand-in-hand, although too frequently the importance of instruments has been overlooked. Without Galileo's invention of the telescope and Tycho Brahe's exact and careful observations of the planets, even the genius of Sir Isaac Newton could not have formulated the laws of motion, the theoretical basis for almost all modern mechanics. Medicine left the realm of witchcraft with the invention of the microscope. Until the spectroscope was developed, physicists were utterly unable to explain the chemical and physical nature of atomic phenomena.

In the automatic electronic computer scientists and engineers have a new instrument for research which may prove as upsetting to current scientific theory as any. As one eminent mathematician says, "Now, we can play our hunches." Up to now, when physicists, mathematicians, engineers, economists, biochemists, and their colleagues in other sciences got ideas (or hypotheses) they often found it impossible to test their validity. Handling of raw data by old-fashioned methods frequently took months or years. Take the case of Doctor D. R. Hartree, the English physicist, who spent 15 years in calculations on atomic structure. With electronic computers his work could have been telescoped into hours, or days at most.

For the first time, technical men are freed from the enormous drudgery of calculation. At last they are free to think.

A Better Standard of Length—The Green Line of Mercury 198

Since 1889 the world's standard of length has been the "meter" which is the distance between two lines on a platinum-iridium bar at the International Bureau of Weights and Measures in France. Fundamental measurements in industry and science are based on this standard, but it has several disadvantages. Line standards are unsuitable in certain fields of measurement, the intrinsic nature of lines ruled on surfaces limits the precision attainable, and finally, the meter is not readily reproducible.

DISADVANTAGES OF CADMIUM

Because the standard meter does not afford sufficient precision in some fields, the red line of cadmium has been used for precise measurements. However, the cadmium standard also has serious disadvantages. First, there is a fine structure in the red radiation which prevents the line from being as sharp as desirable, thus limiting the precision possible. Second, this standard requires excitation in a furnace which entails unwanted broadening of the spectral line because of the relatively high temperature.

A new and better standard of length now exists in the wave length of green radiation of mercury 198, an isotope transmuted from gold by neutron bombardment. In precision, reproducibility, and convenience, the green line of mercury 198 is superior to both the standard meter and the red line of cadmium according to recent investigations by Doctor W. F. Meggers of the National Bureau of Standards. Preliminary measurements have indicated an accuracy of one part in a hundred million of relative values, and one part in a billion is possible theoretically.

In operation, an electrodeless lamp containing several milligrams of mercury 198 is excited by radio waves of 110-megacycle frequency. The light thus generated and light from a cadmium lamp are made to pass simultaneously through a Fabry-Perot interferometer into a prism spectrograph where interference patterns of each spectral line are photographed. Relative values of wave lengths are derived from measurements of the interference patterns.

Wave lengths of natural mercury cannot be used as standards of length because natural mercury consists of a fixed mixture of seven isotopes and each one emits one or more spectral components none of which are exactly coincident. Consequently the green line of natural mercury has 16 components, and the effective wave length of such a complex line observed interferentially varies with the phase relations of the various components. This objectionable feature of natural mercury lines is overcome by using a single isotope of mercury.

Engineering in Europe Today

C. M. FOUST
FELLOW AIEE

The observations of the author, recently returned from a trip abroad to attend the 1947 International Electrotechnical Meeting at Lucerne, Switzerland, indicate that engineering development is making fairly good progress both in England and on the continent of Europe. However, material shortages and the disturbed economic situation in general still present serious obstacles.

THE ENGINEER in Europe is quite like the engineer in the United States in regard to what he would like to do and what he is able to do. From a technical angle he sees many places where he could do things that would contribute to the economic welfare of his people, but circumstances beyond his control often prevent his doing them. European engineers today are interested in much the same problems as we are, but they are hampered by disturbed economic conditions and serious shortages of materials.

ENGLISH DEVELOPMENTS

I had opportunity to observe the situation during my recent visit to Europe (October 1947). Though the principal purpose of my trip was to attend the International Electrotechnical Meeting at Lucerne, Switzerland, I wanted to see something of English electrical developments and so I stopped first at Rugby, England.

Rugby is the home of the electrical manufacturing concern known as British Thomson Houston, which manufactures a wide range of electric apparatus for power uses as well as for domestic uses. Its factories were occupied completely with production of all kinds. The working personnel was alert, active, and able to get things done. Comments from engineers and supervisors indicated that the most important production difficulty was lack of raw materials. The government program of raw material allocation seems to mean that not very many things are immediately at hand when needed, and production schedules are affected greatly by this material shortage.

Engineering work is proceeding in many of the same fields that we are pressing in this country, fields such as short-wave induction heating, silicone products, improvement of magnet steels, flaw detection in solids by supersonic waves, thyratrons for radar, and electron optics. Some of this work is over and above the general engineering design work on production equipment. In view of the necessity of increasing production to meet both the domestic needs as well as the export program, it is necessary to give attention to what is called "reproduction engineering," which, in our language, is engineering on manufacturing processes.

A research laboratory group is at work on an experimental betatron of the 10-million-volt size for high intensity X-ray or gamma radiation. This betatron is being assembled in two wartime bomb shelters. The thick concrete walls and underground location take care of the hazard of stray radiation. It is gratifying that at least two bomb shelters can be used for the purpose of expediting systematic research.

Work was proceeding on a 5-day basis similar to ours. Unemployment is claimed by the government to be as low as two per cent and my casual observation detected practically none. Rather, there seemed to be a spotty lack of manpower.

My next visit was to the Metropolitan Vickers Company in Manchester. This company has an organizational setup built around a technically trained and experienced engineering staff comparable to those in the industries of the United States. Electric power machinery, such as motors, generators, transformers, and switchgear, are the most important products. These are highly engineered and reliable in performance. The English power grid provides an electrical service, when sufficient fuel is available, entirely comparable to that in our heavier population centers.

At the Metropolitan Vickers Company activities and experimental work are being pushed as rapidly as possible under the prevailing conditions of material shortage.

In the field of high-voltage development there is being conducted a wide range of experimental and testing work utilizing one million volts alternating current, one-half million volts direct voltage, and three million volts surge voltage. High-speed cathode-ray oscillographs recording surges in microseconds were in operation as well as transient voltage analyzers to study surge mechanisms of windings and circuits. A 20-million-volt betatron is under construction and a 375-million-electron-volt synchrotron is being designed.

In the physics section several mass spectrometers for chemical analysis have been built and considerable attention is being given to design and manufacture of

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large sized high vacuum diffusion pumps of 20- and 30-inch diameters. Diffusion pump theories of Langmuir and Gaede are being given renewed attention in view of possible improvement through better understanding of basic design considerations.

There is considerable activity in the electron microscope field. A prewar German Siemen's 100-kv electromagnetic focus type is in operation for comparison with Metropolitan Vickers own design. The latter is reduced greatly as to size, with improved and simplified controls and still of equal performance characteristics. Supersonic flaw detection in solids is in progress and studies are being made of sound wave propagation as a means of materials analysis.

At the Switchgear Testing Company, I went over the testing equipment in considerable detail, particularly measurement methods. The magnetic oscillograph appears to be particularly well arranged and speedy in operation. The film exposure chamber is so located that the film holder can be slipped directly from the recording position to the dark room. The cathode-ray oscillograph is a cold cathode continuously pumped type with a 15-kv cathode excitation. It is slow in operation but the records obtained are of good quality. Testing facilities are being enlarged. A new high-voltage transformer building is about completed and additional generator capacity is being planned.

A new Associated Electric Industries research laboratory is being built at Aldermaston Court, Berks, near Reading. This laboratory will do research work pertinent to production of all Associated Electric Industries associates such as British Thomson Houston, Metropolitan Vickers, Fergusin-Pailin, and Ediswan. Aldermaston Court is a 12th century castle, used during the war as an American Air Corps Center. The old castle is being equipped to serve as general office, library, guest quarters, and conference center, without altering the building or grounds except to introduce modern services and to keep them as inconspicuous as possible. When completed it will be a modern research center in a medieval setting and a very attractive place to visit.

Research groups on particular projects each will be located in separate buildings scattered over the grounds of the old estate. At present, work in a number of fields already has been started with a total personnel of approximately 150 people, about 30 of whom are technical. These projects are basic research and include electron optics, metallurgy (amalgamation of metals), thin layer phenomena, and surface physics.

THE BRITISH OUTLOOK

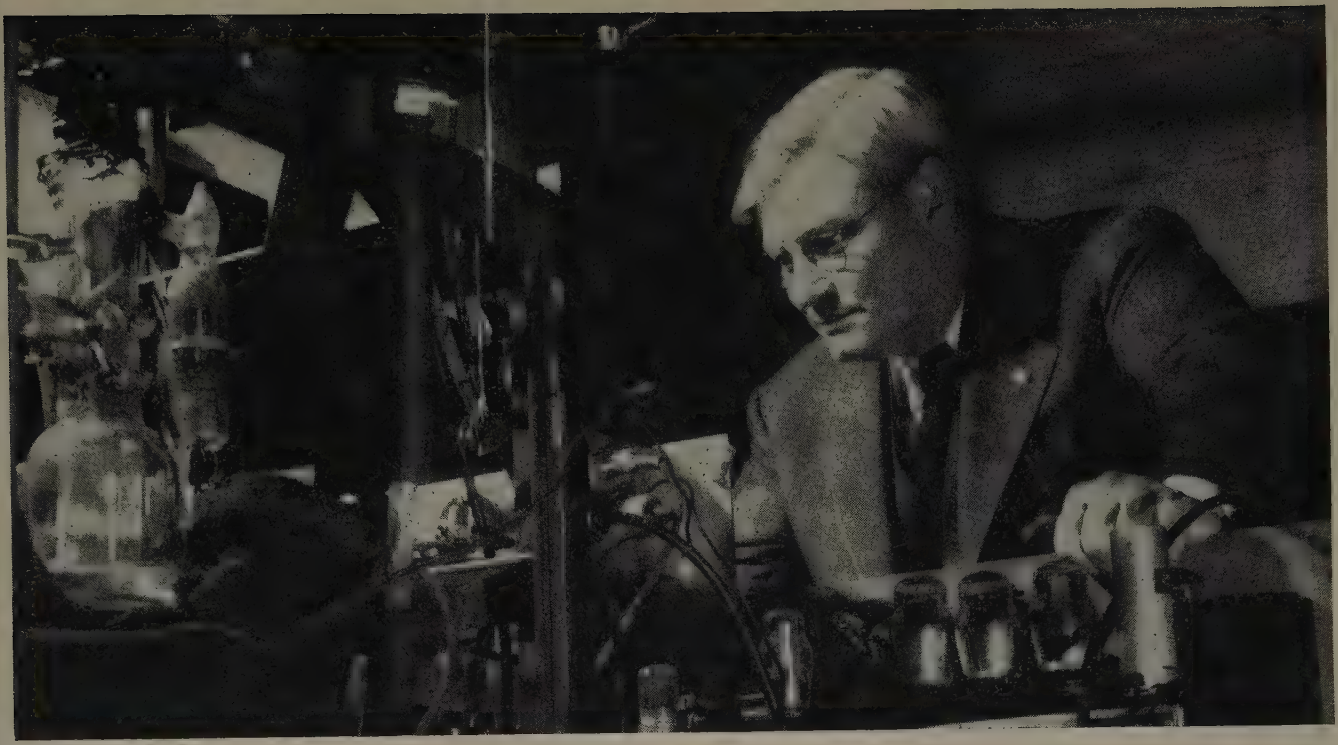
Engineering education is of great interest to many young people in England, and technical schools are filled with students. The combined apprenticeship and co-operative pattern of technical education requires great perseverence and high standards. On the theoretical side technical education is good. Engineering problems are approached from a decided scientific standpoint.

Every Britisher with whom I talked is conscious of the critical period of economic readjustment England and the world are passing through. He is aware that this period is especially important to him and that England's place in the world of the future will depend upon the outcome of present events. In spite of the meagerness of present supplies of food and gasoline and the coal shortage he is not grumbling or blaming the situation on internal politics or the conduct of other nations. He knows that a new world is shaping up and that England's position in it will depend on English work and sacrifice. He has a strong liking for free enterprise but he is convinced that co-ordination of effort is also necessary. He does not shrink from national planning but believes that it must include as much planning for free enterprise as is compatible with the best that can be gained in his living standards. He sees his problem as not complete business freedom against complete national planning, but rather as: Where are political control and economic planning required and where can individual freedom of initiative be stimulated to advantage?

As an individual he is chagrined over his postwar economic plight but is quite self-reliant and determined to overcome his difficulties at almost any cost. There is, of course, in common with that in other countries, a mass insurgency motivated by dissatisfactions with old world forms and resulting in the fading or prestige of old institutions, both political and economic. Rationing is succcessful because people at all levels of purchasing power recognize that only through rationing can some justice be served to all in the distribution of material goods. There is no black market because Britons who have buying power to use it are conscious of its over-all injustice to the low income groups. If England wins this battle, and I believe she will, I think it will be because her people are standing together and individually are determined to win even though it has to be done the hard way.

ELECTRIC POWER IN FRANCE

From England, I went to Paris, France, where my first visit was to Mr. Alleret who is in charge of high-voltage transmission planning for the French government. He outlined the European power transmission situation, pointing out substantial benefits to be obtained through interconnection of existing transmission in France, Germany, Switzerland, and possibly Sweden. A considerable amount of 220-kv transmission is now in operation in France, Germany, and Sweden. Interconnection for exchange of power at a voltage as high as 380 kv is required in his estimation. On his invitation, F. Cahén, manager, high-voltage research department, Electricité de France, took us out to an experimental high-voltage substation at Chivally on the outskirts of Paris where corona tests up to 500 kv have been in



The author at work in the laboratory

course of operation since the Fall of 1946. A double conductor arrangement, being studied, is considered especially attractive from both corona loss and stability standpoints.

We next visited Mr. Morand at the Hospital Curie where a 500-kv regulated direct voltage is obtained from a kenotron rectifier set using 250-kv rectifier tubes. A current load of 10 milliamperes is available. It is planned to use this voltage for particle acceleration. This is also the control laboratory for French cosmic ray measurements. A cosmic ray counter consisting of a bank of nine Geiger tube counters has been built and used and is now under adjustment. Special electronic circuits provide for integration of tube operations on a paper record. A Wilson cloud chamber is also in operation. The cosmic ray and cloud chamber work is done by Mr. Cahén.

We also visited the College de France where a proton microscope laboratory setup is being assembled. No work on protons has been done as yet as a good proton source is still not available. A mass spectrometer also is being built at this college.

A trip to the Conservatore Nationale des Arts and Professions proved very interesting because it is located in an 11th century monastery and is a scientific museum and public technical lecture school, as well as a testing and experimental station. In the museum are such originals as Bleriots cross-channel airplane and other and older aircraft from the days of early aeronautical pioneering. Some 25,000 regular listeners are enrolled each year in the public scientific lectures held in modern classrooms under the old monastery court yard. Mr. Boutry, in charge of the experimental work, showed us equipment for acoustic measurements of elasticity of metals and several X-ray spectrum analysis setups using removable targets. An electron microscope is being used with considerable satisfaction but the diffraction attachments are not considered practical.

At the X-ray plant of the Compagnie Francaise Thomson Houston, there are production facilities for various vacuum pumps, rotary and diffusion types, and a well designed vacuum chamber for vacuum metallurgy of X-ray targets. Another interesting piece of equipment was used for oxygen analysis of metals. The process is to drop a small sample of the metal inside the vacuum into a cup by magnetic control. The metal is melted by induction heating and the vapors trapped by pumping into a test tube through a mercury trap.

By far, the most finished technical equipment I saw in France was the electron microscope at Compagnie Telegraphie San Fil which is about the same as Radio Corporation of America in the United States in that they manufacture radio parts and equipments for industry in general. The microscope is designed by Grivet and Bruck and is very fine in appearance and easy to operate. Features are a solid piece electrostatic focusing element, variable magnification on one control without loss of focus of image centering from 2,000 to 14,000 magnification. The equipment is large and, as compared with Metropolitan Vickers Company, favorable as to performance, but definitely more costly to build.

On my last day in France we visited the Ampere Laboratories at Ivry to see high-voltage equipment. This had been an insulator testing laboratory and contained an excellent 3-million-volt impulse generator, a 1-million-volt a-c test transformer, and two 500-kv d-c sets. The impulse oscillograph was a du Four type. This equipment, except for the d-c sets, was not in use but plans were afoot to get it going on some nucleonics work. The d-c set was in use on neutron experiments.

In France economic conditions are chaotic. Food is short and some articles are rationed but, of course, agriculture is able to supply much more than in England. Electric power also is limited and is available to industry on a 4-day basis. Materials for manufacture are difficult to obtain. Political questions are of great concern, especially in the large cities, and strong conflicting sentiments are contesting for control. The French people seem more concerned over the principles in conflict than the facts of the economic difficulty. The search is on in France for new formulas and new slogans which will remove the destruction of warfare and still permit the everyday Frenchman to feel that he is living his own life.

IEC MEETING

From Paris I went by air to Zurich, Switzerland, and by train to Lucerne to attend the meetings of two advisory committees of the International Electrotechnical Commission held at the Rathous (am Kornmarkt) during the week, October 20–25. In all, four advisory committees held sessions: radio communication, electrical accessories, extra-high voltages, CISPR (Committee International Special des Perturbations Radiophoniques) group of experts.

Many countries were represented and a very serious and enthusiastic interest in technical problems was evident. The desire to exchange useful technical information and to realize savings resulting from well-considered standardization were the conspicuous qualities of the conventions very co-operative atmosphere. Those countries represented, with their respective number of delegates, were: Austria (2), Belgium (12), Denmark (2), United States (6), France (11), Holland (10), Italy (9), Norway (2), Great Britain (18), Sweden (5), Switzerland (31), Czechoslovakia (8).

All sessions were in French and English, and the double language standard resulted in some time lost and occasional confusion. However, it is not clear how this problem could be handled otherwise.

My principal interest was in the sessions of the Committee on Extra-High Voltage on Monday and Tuesday, and CISPR (almost entirely radio noise) on Wednesday, Thursday, and Friday.

The chairman of sessions for the former committee was Mr. Ailleret and meetings were well conducted and attended. The objective of this committee is the standardization of high-voltage transmission and interconnection levels. The agenda was made up of three general items:

Review of replies to questionnaire on status of present transmission practices and plans for the future.

Aspects of standardization of extra-high voltages pertinent to future interconnection.

Aspects of standardization of extra-high voltages pertinent to equipment construction and insulation levels.

The reports from some 12 countries on the several items in the questionnaire were surveyed, thus providing for some understanding of the present levels and practices of transmission and interconnection, as well as the thinking in these countries regarding line extensions. Highest nominal voltages for transmission range, according to this report, from 50 kv in Denmark to 287.5 kv in the United States. Six countries operate at 200 kv or higher on at least one line. For the future, thinking in several countries is toward higher voltages, both for system extension and interconnection. In France, interconnection needs have suggested levels ranging up to 400 kv. In Great Britain, plans have been completed for construction of one 264-kv line. In Sweden, it has been decided to build a 350-kv system. The Swiss are focusing their thinking around 380 kv. Opinion seems quite general that one or two voltage levels above 220 kv will be enough to standardize. If 287 kv continues to find favor, this would be the first step, with a second somewhere between 345- and 400-kv nominal voltage.

The chairman called attention to three developments expected to mature within a few months and pertinent to technical problems concerned with the selection of standard line voltages. First, a 500-kv 3-phase experimental setup designed to provide high-voltage data has been in operation at Chivally Station near Paris about six months and will be reported upon soon. Second, another experimental high voltage at the Tidd Station of the American Gas and Electric Company is about ready for operation and shortly will provide useful data. Third, the CIGRE (Conference Internationale des Grandes Réseaux Electriques à Haute Tension) is planning a 1948 Paris session on large high-tension systems which will include almost all phases of the high-voltage transmission problem.

In view of the near availability of additional data and analyses, the Lucerne meeting did not wish to reach final agreements on voltage levels. However, to crystallize the discussions of the several sessions, a committee was appointed to draft a digest of deliberations. At the end of the sessions, and before final editing, this digest read as follows:

The following countries, namely, France, Italy, Portugal, Switzerland, Sweden, and Czechoslovakia, several of which have discussed the question of higher voltages with a view to approaching the voltages under consideration in the United States, are prepared to agree to a voltage level defined by the following figures:

Average Operating Voltage (Space-Time)	Maximum (Space-Time)
380	400

The United States, in its reply to the questionnaire, has referred to the possibility of a voltage level being adopted in which the maximum voltage would be 386 kv, but, as the tests at present being undertaken on its experimental line will be an important factor in fixing the figure, it would be advisable to wait the results of these tests which the United States committee kindly has agreed to transmit to Committee 30 (Committee on Extra-High Voltage) before taking up a definite position and discussing the possibility of reaching a general agreement.

In regions where 220/242 kv already is employed or intended, it is considered undesirable to introduce an additional voltage which does not give a considerable step in power delivered. Further, it is desirable, when choosing voltages for application, to have in mind that in the large regions now in consideration special problems suggesting intermediate voltage steps later may be overshadowed in ultimate economy by the need in 10 to 20 years of large-scale interconnection between such regions.

The transport of power from the Boulder Dam to Los Angeles is now the only instance of the employment in commercial operation of a voltage of 287 kv (275 average operating voltage with 303 maximum). If Great Britain chooses the same voltage for its new lines, the development of the use of this voltage, including the possibility that it may be accepted in other particular cases, would justify its inclusion in the list of International Electrotechnical Commission standard voltages. Nevertheless, in view of the proximity of this voltage to 220–242 kv, it definitely should be stated that it only should be considered as a standard voltage in those regions where this voltage is already in use, or in those where 220 kv (average) is not yet used. By the term "region" is understood in this instance a sufficiently extensive region to include all the interconnection which one reasonably may consider could be justified economically within the next 20 years.

The relation of insulation levels to operating voltage was, of course, right in the middle of the voltage level problem and much discussion ensued on it. However as this subject is the responsibility of Committee 28 it was agreed to transmit a memorandum to this committee inviting recommendations. The preliminary wording of this memorandum is as follows:

In the view of Committee 30 the discussions regarding insulation level for networks of higher voltages than 220 kv should start with the establishment of internationally agreed recommendations, that is, the relation between insulation level and operating voltage in systems with operating voltages in the range of 150–220 kv.

Committee 30 therefore invites Committee 28 to put forward such recommendations. Further, Committee 30 suggests to Advisory Committee 28 that it ascertain as to whether the afore-mentioned recommendations could be adopted also in systems with operating voltages in the range of 380 and 400 kv (maximum voltages) or whether special recommendations for such systems should be developed, taking into consideration the influence of extremely long lines and so forth. Committee 30 suggests that the recommendations for extra-high-voltage systems be based on the assumption that the neutral of the system is solidly grounded.

Attention was called to the present IEC standard voltages with the observation that voltages actually in use are quite different. Also, some considerable discussion was had over the use of the terms "nominal," average, maximum, and so forth. As these matters come within the responsibilities of Committee 8, a memorandum calling attention to them was drafted. The translation before final editing of this memorandum is as follows:

Committee 30 calls the attention of Committee 8 to the following points:

1. The maximum voltage in normal service is the most important element in assessing the voltage of a system, as it conditions the operation of the equipment.

2. The average voltage, however, is an important element from the viewpoint of the possibilities of direct interconnection between systems. A precise meaning should be given to this voltage by adopting the arithmetical mean of the voltage both in space and time. In thus taking into account the whole system, we abandon the former concept of "receiving end" which has no longer any precise meaning so far as many of the present extra-high-voltage systems are concerned.

3. It seems essential to revise the IEC standard voltages for very high voltages as the voltages actually in use are substantially different from them.

For instance, the systems called, according to the country, 200, 220, or 230 kv, operate in fact under such similar conditions that, from the sole viewpoint of voltages, there would be no difficulty to interconnect them or to transfer equipment from one to the other.

The arithmetical mean voltage in these systems is close to 220 kv and the maximum voltage goes up to 242 kv. These actual conditions are thus very different from those of IEC standards (200 average at the receiving end, 220 maximum).

4. Committee 30 leaves it to Committee 8 to reconsider entirely the agreements regarding the term "nominal voltage." taking into account the actual position as pointed out.

RADIO INTERFERENCE SESSION

The CISPR meeting on radio interference was a very lively one attended by some 57 delegates. The chairman elected was Doctor S. Whitehead of England with Doctor W. Gerber of Switzerland as vice-chairman.

Delegates from each nation reported progress since the last meeting on November 8, 1946.

Mr. Morren of Belgium reported on design developments in the CISPR noise meter, noting especially an increase in linear overload capacity to 34 decibels by replacing the last intermediate frequency tube by a power pentode.

Mr. Thomas, for the United States, described Bureau of Ships measuring set *TS 587/U* covering the range 15–400 megacycles, using both the slide-back method of peak measurement and direct measurement of quasi peaks, and Mr. Beizer for the Signal Corps described measuring set type *AN/URM/3* employing a pulse calibrator with variable repetition frequency, and a slide-back voltmeter. Both these instruments were demonstrated at the Rathous.

For France it was reported that some work had been done on the manner in which interference reaches and affects receivers.

Netherlands' experts described comparison tests between the Belgian CISPR noise meter and a wartime rebuilt meter which showed very satisfactory agreement.

The United Kingdom report covered a number of items and indicated very active work. These included recommendations to make only line-to-ground measurements, comparison of audio and radio-frequency methods, a compact smooth noise source, measurements of noise fluctuations by means of a diode voltmeter, subjective effect of repeated impulses, and a skeleton form of television receiver for automobile ignition interference tests.

Switzerland reported on statistical measurements of impedance of high tension on lines and suppression of interference from electric railways.

Czechoslovakia emphasized the importance of prevention of noise at the source rather than its cure. Manufacturers were co-operating to design appliances to be as far as possible free from interference.

To accomplish the many phases of this interference work the chairman set up three committees to work concurrently:

Committee 1: assessment of discontinuous interference
Committee 2: coupling and networks
Committee 3: instrument calibrations

Subcommittee 1 arrived at certain conclusions on which are based the following conclusions (in part):

1. When a recording instrument is used in place of, or in conjunction with, an indicating set of the CISPR type, the time constant shall satisfy the requirements for the indicating instrument for a measuring set of this type.

2. A wide range instrument of at least a range of 100 to 1 appears to be necessary for assessing a number of types of interference. In general a solution to this problem has been sought by means of an instrument embodying a logarithmic scale law. This still appears the most promising line of attack, but further study is required.

3. When assessing impulsive interference, two types of interference were recognized:

(*a*). Interference as a result of discrete pulses alone.

(*b*). Interference as a result of discrete pulses in the presence of a background of smooth noise where the background noise may be the more important factor in producing annoyance.

In case *a* two methods experimentally used for assessing the annoyance value were reported:

1. By counting the number of impulses which exceed several given levels (for example, three levels in decade steps) to give an estimate of the distribution curve.

2. By noting the percentage of impulses which exceed a given level in a sample and applying statistical methods to predict the distribution.

It was noted that both of these methods also require a knowledge of the repetition rate to assess the annoyance. It was noted further that the foregoing methods of assessment assume a priori that the interference is solely impulsive.

In case *b* where the background noise may be significant it was noted that existing meters of the CISPR type were influenced largely by the impulsive component and gave an incorrect estimate of the annoyance.

It, therefore, was recognized that a new type of meter is necessary and it is required to determine what features of this combination of types of interference need be specified for a correct assessment of the annoyance.

Subcommittee 2 received reports from each country on networks in use and discussed each under the able leadership of Doctor Gerber.

With regard to the symmetrical or assymmetrical measurements, it was agreed that where routine values quickly taken were required, the line-to-ground values would suffice in many instances. However, in view of frequent need for complete information, the network would have to be suitable for line-to-line measurements. While lower values of network resistance generally were favored, it was recognized that careful consideration might have to be given to proper selection of resistance in some instances.

Subcommittee 3 reported through Chairman Marven in part as follows. It was agreed that a calibration must be done on a sinusoidal signal as well as on impulses. If two sets agree on a sinusoidal signal, but not on pulses, the cause of the discrepancy should be determined and corrected.

It was agreed that if all noise measuring sets were alike in circuit and constructional detail, they could be calibrated by a sine-wave standard signal generator with, perhaps, an incorporated relaxation oscillator "shot-effect noise" source or continuous wave oscillator for initial gain setting.

It also was agreed that if all measuring sets were required to give the same responses to all types of interference, this probably would require that the sets should be of identical construction.

It, therefore, appears that the function of a pulse-generator calibrator is the correlation of the different indications given by different measuring sets for different types of disturbance. The calibrator, therefore, should be capable of simulating the widest possible range of disturbances, from single or infrequent impulses to "smooth" noise.

The conclusions of the subcommittee, based on the foregoing reports and considerations, are given in the following. These conclusions are limited to measurements and calibrations in the frequency range up to 20–30-megacycles per second.

1. It must be recognized that the various types of radio-noise measuring sets in use now and in the near future may differ among themselves in their measurement of different types of disturbance.

2. There is, therefore, a need for a type of calibrator which will make it possible to correlate such differences with the type of disturbance.

3. It is considered that a calibrator suitable for this purpose is a source of pulses of known amplitude with a known and adjustable pulse repetition rate.

The values of pulse repetition rate proposed are

0 (that is, a single pulse)
5..............per second
50..............per second
500..............per second
2,500..............per second
5,000..............per second

Note: A pulse repetition rate even higher than 5,000 may be found desirable if it can be realized without undue difficulty, but special phenomena may arise when the repetition rate is numerically of the order of, or exceeds, the bandwidth.

The form of the pulses should be such as to give a substantially uniform distribution of energy with frequency up to 30 megacycles per second, and to be capable of repetition at frequencies up to at least 5,000 cycles per second.

From the description of the calibrator already referred to (report *C63/58*), it appears that these requirements can be met by pulses derived from the discharge of a capacitor to $1/e$ of its initial potential in 0.01 per second.

The subcommittee recommended that the national committees endeavor to design and construct pulse generators for the characteristics described, with a view to their subsequent intercomparison.

This brief report of activities of these committees does not do justice to the careful consideration and comprehensive reporting of each subject. It also is to be understood thoroughly that the final reports on both high voltage and interference will be authoritative. These will be available through J. W. McNair (A '25) secretary of the United States National Committee of the IEC or through technical advisors.

THE SWISS SITUATION

On the last day of my stay in Switzerland we set out by automobile to visit a high head power generation station at Innerkirche among the mountain tops. This was the most scenic occasion of my entire trip. Two power stations of 1,770 feet and 2,200 feet head in series are fed from mountain top glacier lakes at 6,200 feet elevation. The upper level lake was found to be under a recent eight inch snowfall, which made its approach over narrow mountain roads hazardous. We visited both of the power stations, however, one of them built inside a huge cavern and completely covered by thick rock masses of the mountain.

The Swiss are in the best position politically and economically of any of the peoples of Europe. The store windows are filled with goods of all kinds and neatly arranged with the price on each, and, more than that, what is in the windows is sold inside and at the prices advertised. The most striking impression I got was that of cleanliness and orderliness everywhere. People were well dressed and busy. At the Sweitzerhof in Lucerne where I stayed service was very elaborate. Food is rationed, but apparently on a sufficiently liberal basis to be quite adequate. There seemed to be no unrest except possibly some fear of another great world war. While the Swiss were fortunate not to be directly involved in the first two wars, they seem to understand that these wars were reflected in their living standards, and that another would so depress world economic levels that high living standards would not be possible at home. The best interpretation of present Russian government policy I heard came through contacts in Switzerland. It held that Russian leadership was concerned most of all with the problem of maintaining political control in Russia. All devices of political propaganda and news censorship were designed to serve this end. Next came a positive fear in Russian leadership that the western democracies were by indirect methods seeking to undermine political and economic objectives of the Russian Communist party. The party leadership, conscious of the comparatively low standard of material life in Russia, considered its freedom of action and prestige to be in serious jeopardy if the Russian people were to be permitted to make factual comparisons. The results are the "iron curtain" and the international political policy of belligerent independence of action. This interpretation does not admit of a Russian policy of imperialism or a definite program of communist infiltration within other nations at this time.

RETURN TO ENGLAND

On completion of the IEC Conference I went by train across Switzerland to Geneva and then returned to England by air. On my return to London I visited the British Thomson Houston switchgear plant at Willsden. In the high-voltage laboratory a 2-million-volt impulse generator is in operation and it is used quite frequently on commercial tests. The cathode-ray oscillograph is a sealed-in type used with a delay cable. A power system network analyzer has been built at Willsden and is now ready for use. It is a very nice looking setup and built pretty much along the lines of American 400-cycle analyzers. The analyzer has been taken over by Associated Electric Industries for general use of affiliates and also will be used on rental basis by operating groups where required.

A summary of the technical situation in England and Europe indicates that production of manufactured goods is moving but limited below what it should be by lack of materials. People are working and generally willing to work more if assured of some return. Research and development is going ahead somewhat but mostly on paper, as elaborate equipment cannot be financed or built from the limited materials allocated.

In reference to the socio-economic situation, it seemed clear to me after talking with many people that there was much less faith in the effectiveness of any organizational pattern or procedure and a strong conviction that the solution of present problems awaits a deeper sense of mutual dependence and responsibility. The old formulas of economic and political bargaining do not seem adequate to the preservation of the best of our great material culture. Many are convinced that even a present recovery without the addition of a cleansing, moving force would but eventually end in another war with an irrecoverable loss of material and mental substance. Only a reconciliation of ideologies, a stimulation of interest in things of the spirit of life, and progress in humanics will preserve and extend the good we already have achieved.

A New Mechanical Demand Meter Register

J. R. MACINTYRE
MEMBER AIEE

R. W. SNYDER
ASSOCIATE AIEE

A new mechanical demand register using a Geneva-type mechanism to accomplish both the timing of the demand interval and the resetting of the pointer-pusher has eliminated the energy storage spring with its design and maintenance problems.

MECHANICAL-TYPE demand meter registers mounted on integrating watt-hour meters are important devices in the field of electric power metering, because public utilities often sell their electrical service at a price proportional to the maximum power demand. The sale of electrical service on this basis frequently is considered more equitable than straight energy billing based upon watt-hour meter readings, because the cost of service is determined partially by the investment in sufficient equipment to meet maximum power demands. However, in practice, the use of demand meters is not as extensive as that of watt-hour meters, because of the additional investment in meters necessary.

The register performs five distinct functions: watt-hour registration, pointer-pusher and demand pointer advancement, interval timing, interval resetting, and accumulation of maximum demand when the reading is taken. A new register has been developed to surpass the performance of previous demand registers.

The watt-hour registration is performed by a conventional mechanism consisting of a train of gears between the meter disk shaft and the indicating pointers.

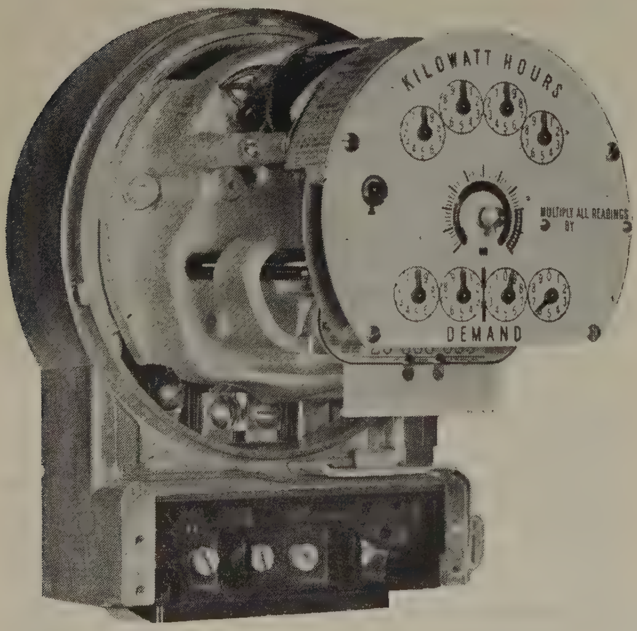


Figure 1. New demand register mounted on a single-phase watt-hour meter

The pointer-pusher and demand pointer advancing mechanisms are also similar to those which have been used for some time in demand registers. The watt-hour meter disk shaft is geared to the pointer-pusher through a clutch system. The pointer-pusher, as it advances proportionally to the energy being metered, pushes a demand indicating pointer which is restrained by a friction clutch. The timing of the demand interval is accomplished by a synchronous timing motor similar to that used in electric clocks. The actual timing operation and interval resetting operation are performed by a common mechanism.

The interval resetting mechanism represents the major contribution of the new design to the metering art. The application of a Geneva gear mechanism to the resetting and timing function was a natural result of a study of the desired action. This action basically involves the partial rotation of a reset shaft at fixed intervals. A mechanism basically similar to the ordinary automobile cyclometer mileage indicator is used in the register. The equivalent of the first gear is driven continuously by a synchronous timing motor and the intermittent rotation of another gear at fixed time intervals is used to drive the reset shaft to reset the pointer-pusher in a manner to be described.

The intermittent rotation of the reset shaft opens the clutch in the pointer-pusher gear train by the action of a cam riser, and then pushes a pin against the tail of a sector gear which returns the pointer-pusher to zero. The pin then over-travels enough to get out of the way of the sector gear tail for its up-scale movement during the next interval. The cam riser and pin are mounted on a single hub so that the relation of one to the other is maintained rigidly. The resetting operation takes place in five seconds, although the complete intermittent motion of the Geneva gearing takes nine seconds.

The load on the timing motor during this operation is very small. The Geneva gearing is designed so that demand intervals of 15, 30, or 60 minutes can be produced with changes in only one or two parts.

The cumulative reset mechanism, which is of the same general type as has given excellent service in the past, consists of a train of gears, which, when connected

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J. R. Macintyre and R. W. Snyder are engineers at the West Lynn Works of the General Electric Company, Lynn, Mass.

to the timing motor by depressing the knob in the center of the dial, returns the demand indicating pointer to zero. At the same time, the cumulative dials are driven to the new reading. The subtraction of successive readings of the cumulative dials gives the maximum demand for the period.

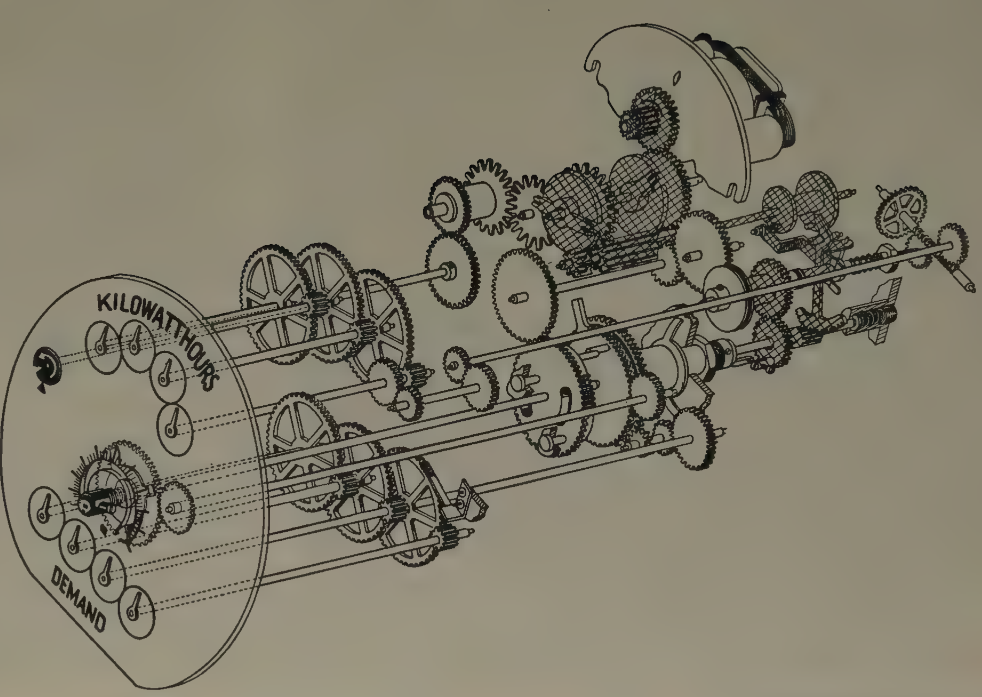


Figure 2. Schematic diagram of the new demand meter register

Timing and resetting portion are shown crosshatched

PERFORMANCE

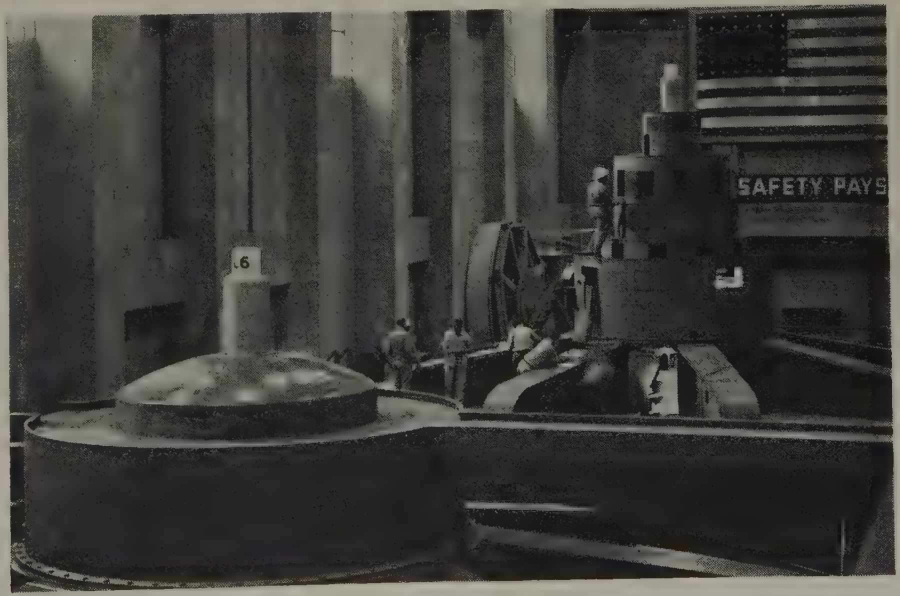
The mechanisms in use in registers of current manufacture were analyzed carefully before the development and the design of the new register were begun. Some of these mechanisms, such as the watt-hour register gearing, were obviously so simple that there was little or no need for change. In the interval resetting mechanism, however, there was a real need for simplification and improvement if the objectives of the design were to be met. As a result, this mechanism received the most attention and represents the greatest improvement over current designs.

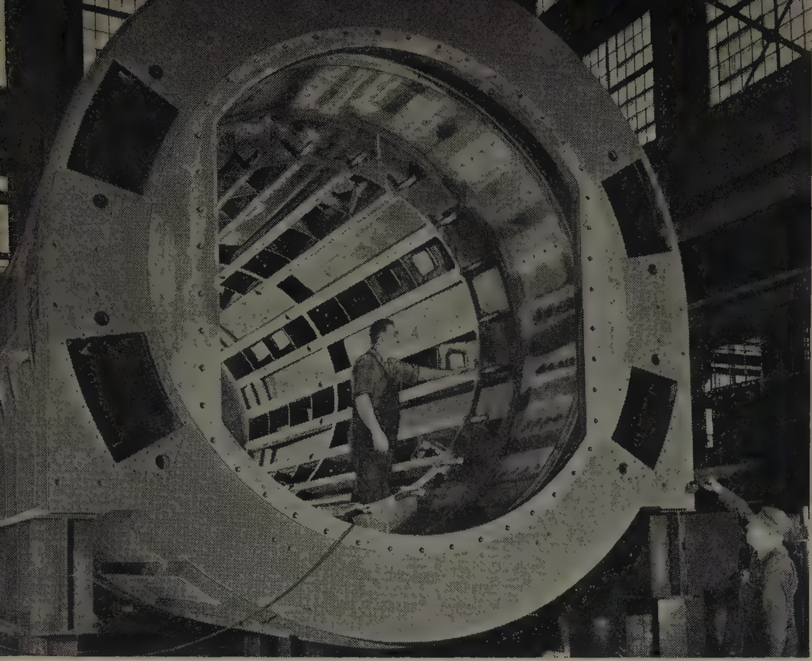
For the resetting function, previous register designs used the energy stored in a spring by the watt-hour meter or the timing motor during the interval between resets. Both mechanisms are delicate, and the first may give a false zero reading.

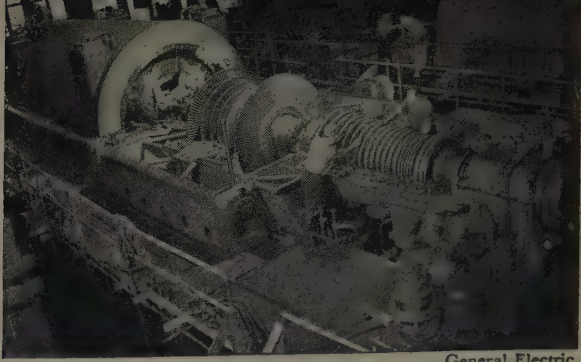
In the new register, the resetting function is positive, because the motor drives the resetting cam through direct gearing. All energy storage springs therefore, have been eliminated and a positive reset feature is inherent in the design. This positive reset operation is obtained with a sturdy mechanism which is simpler than that needed with the energy-storage spring systems. Because of the design of this reset mechanism, the torque required for the reset operation is reduced materially and the energy taken from the timing motor is less than one tenth that of a superseded design. This results in more reliable operation and longer life of the entire mechanism.

Grand Coulee's Seventh Generator

This is the seventh generator to be installed in the west powerhouse of the Grand Coulee Dam in eastern Washington. The new Westinghouse unit (at the right) has its exciter mounted on top of the generator unlike the others which have their exciters mounted on the floor beside them







General Electric

▲ This 50,000-kw turbogenerator being assembled for test before shipment to the Ohio River Power Company is typical of newer designs in power generating equipment

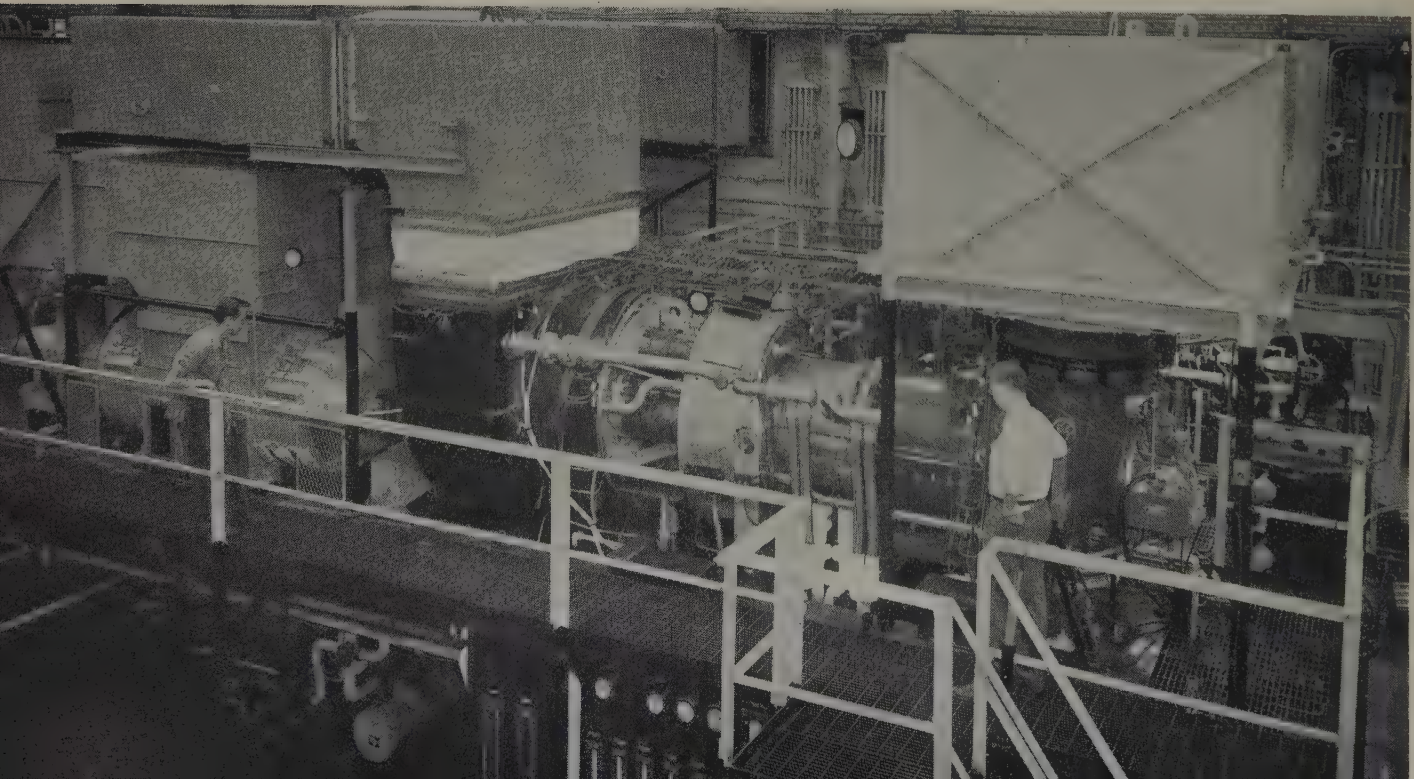
◀ Hydrogen control equipment for this Allis-Chalmers hydrogen-cooled 80,000-kw 1,800-rpm turbogenerator will require no vacuum treating apparatus. Further progress is indicated by the new design stator which incorporates four concentrically mounted coolers reducing generator diameter and height above the floor line. Improved cooling efficiency, together with reduced hydrogen volume, results from this new design. This is the third of four similar sized generators in a midwestern power plant

1947 ENGINEERING

Some of the significant engineering

◀ Typical of developments in large size generating equipment is this 107,000-kw turbogenerator placed in commercial operation last September by Commonwealth Edison Company at its Calumet generating station, Chicago, Ill. It boosts the Chicago area's generating capacity to 2,400,000-kw

▼ A 4,800-horsepower gas turbine power plant, General Electric's first for nonaircraft service, undergoing test runs in the factory

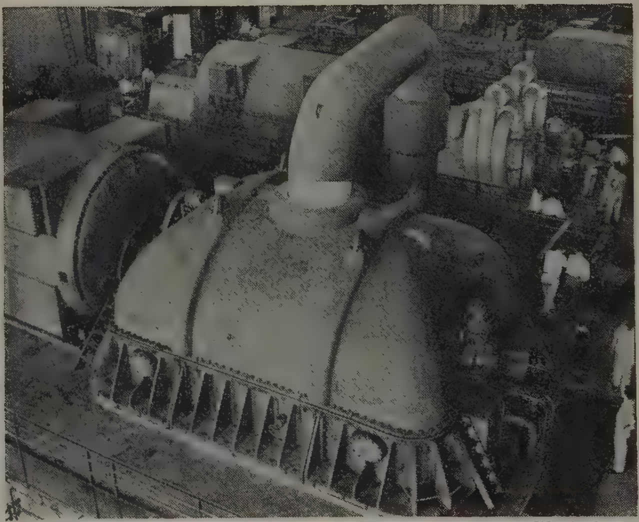


Allis-Chalmers

▲ Built for semitrailer mounting for the Bonneville Power Administration last year, this 2,500-kva mobile substation is completely self-contained including low-voltage switchgear and relaying and metering auxiliaries. Radical departures in design were necessary to incorporate high-voltage ratings from 31.-75kv delta to 110-kv Y with six $2^1/_2$ per cent full capacity taps adjustable by external handwheels, and low-voltage ratings from 2.4-kv delta to 13.8-kv Y, in addition to a 5-kv tertiary winding

DEVELOPMENTS

developments achieved last year



Westinghouse

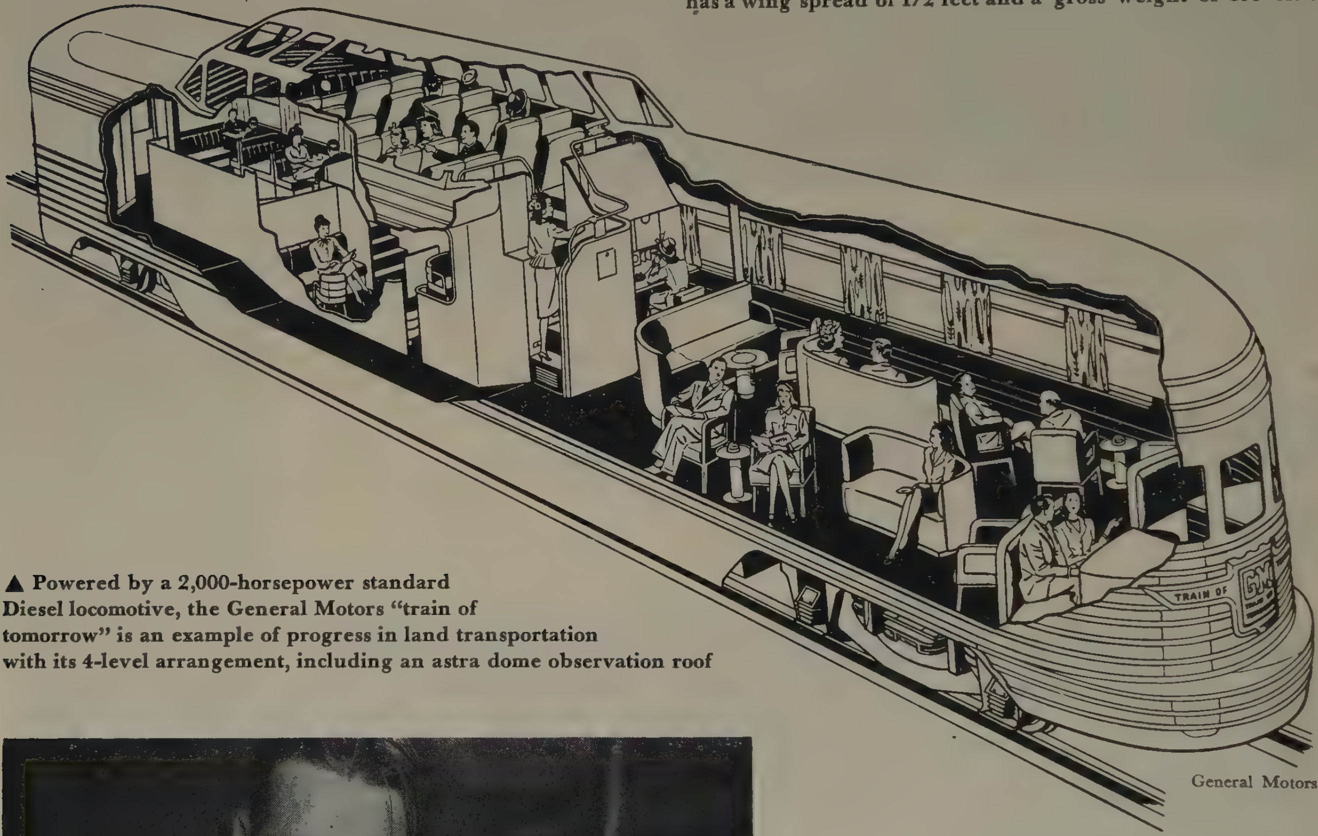
▲The new turbogenerator installed in the Southwark station of the Philadelphia Electric Company consists of a 65,000-kw 3,600-rpm unit and a tandem-compound 85,000-kw 1,800-rpm unit

Westinghouse

◀ A new idea in aircraft window de-icing. Current passed through a transparent conducting film in the airplane window "sandwich" generates heat enough to keep ice from forming

General Electric

▲The Northrop Flying Wing YB-49, one of the United States Air Forces's 8-jet bombers, exemplifies the progress made in jet propulsion. It is shown here making its maiden flight at Northrop Field, Hawthorne, Calif., which lasted 34 minutes. The YB-49 has a wing spread of 172 feet and a gross weight of 100 tons



▲ Powered by a 2,000-horsepower standard Diesel locomotive, the General Motors "train of tomorrow" is an example of progress in land transportation with its 4-level arrangement, including an astra dome observation roof

General Motors

Westinghouse

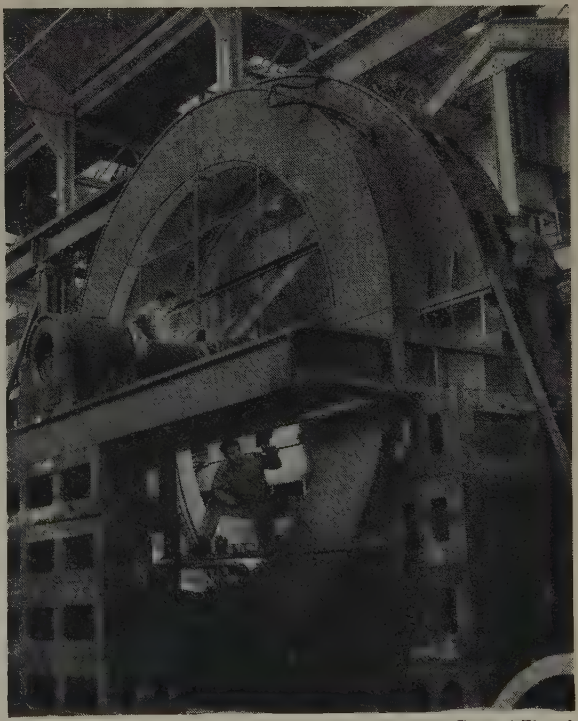
◀ Some idea of aircraft component development can be gained from this 9.24-horsepower 3,600-rpm d-c motor for driving an air-conditioning compressor on a transport airplane. It weighs 53.5 pounds

▶ Another jet propulsion development is the Douglas D-558 Skystreak, with a single axial-flow turbojet engine. It set the 1947 world's speed, with 650.6 miles per hour

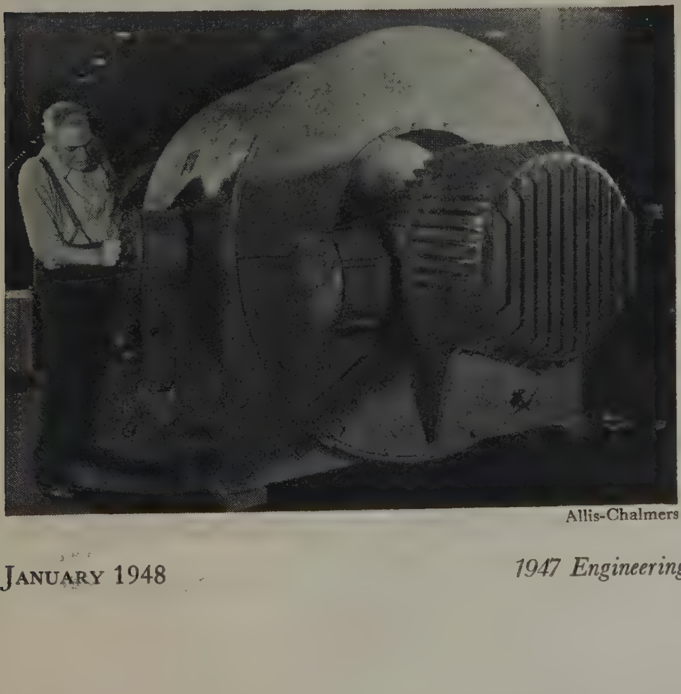
General Electric

◀ Reputed to be the largest single-cab locomotive in the world, this unit developed by General Electric for the Great Northern Railway was put in operation in 1947. The 11,000-volt 25-cycle single-phase motor-generator locomotive has a continuous rating of 5,000 horsepower at the rail with 119,000 pounds tractive effort at a speed of only 15.75 miles per hour

▼ Built to drive a roughing stand of a hot-strip mill this 4,000-horsepower 6,600-volt 3-phase 60-cycle 78-rpm synchronous motor weighs 110 tons



General Electric



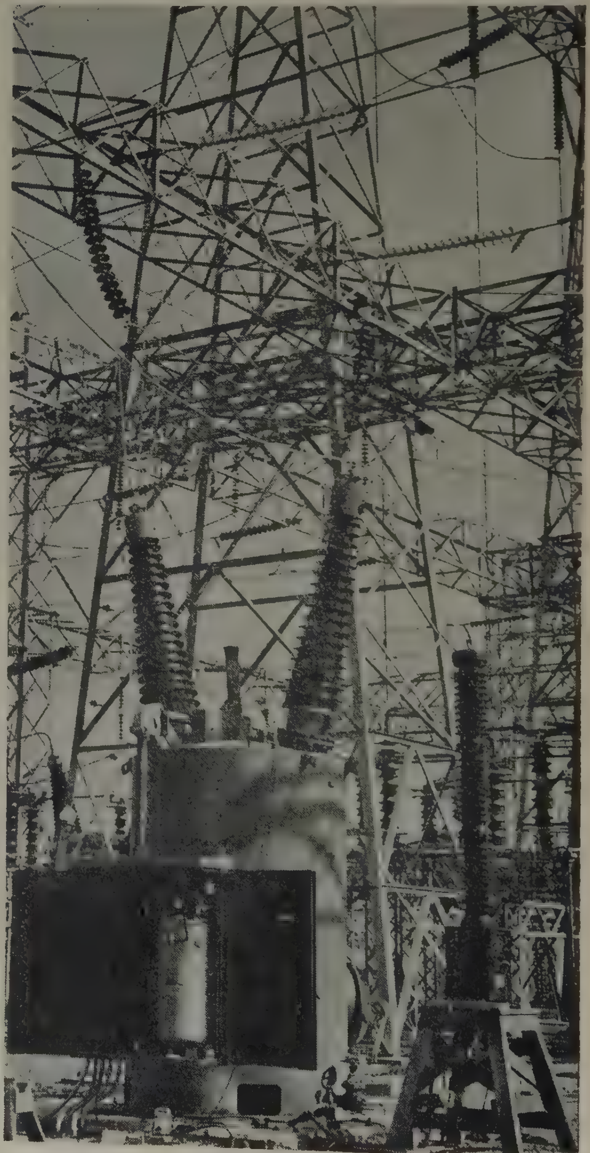
Allis-Chalmers

◀ An example of unusual 1947 motor design is this 500-horsepower 2,300-volt 705-rpm tube-type totally-enclosed, fan-cooled wound-rotor motor for pump drive in a chemical plant. The unit is built with corrosion-resisting stainless steel pants throughout the ventilating system

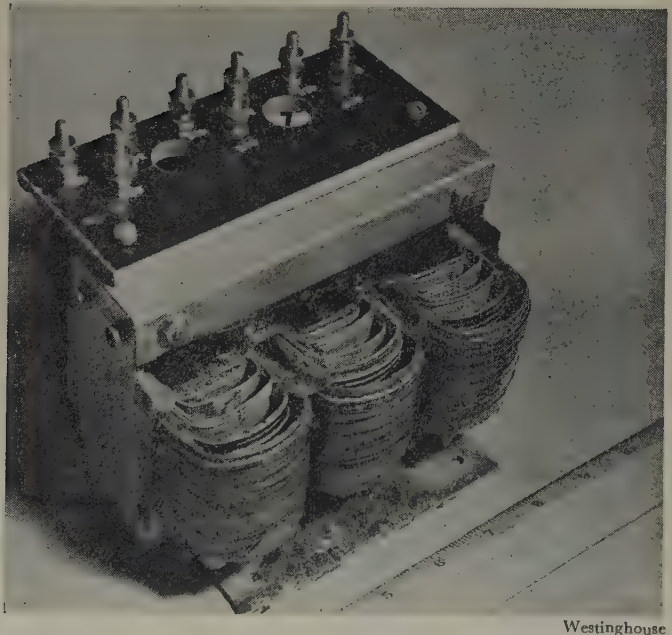
Westinghouse

▲ Rototrols, affording automatic control and regulation over a wide range of speeds and synchronization between different sections, have found new applications in high-speed strip mills

▲ A new design multigrid De-ion circuit breaker tested at Grand Coulee. Two of the short circuits reached a total rms current of 17,000 and 18,200 amperes respectively, and interruptions took place within the rated time of three cycles. The entire Bonneville system and Northwest power pool was tied together and paralleled with Grand Coulee units to perform these field tests which have provided data for construction of a 3-cycle 230-kv circuit breaker rated 10,000,000 kva on 20-cycle reclosing duty



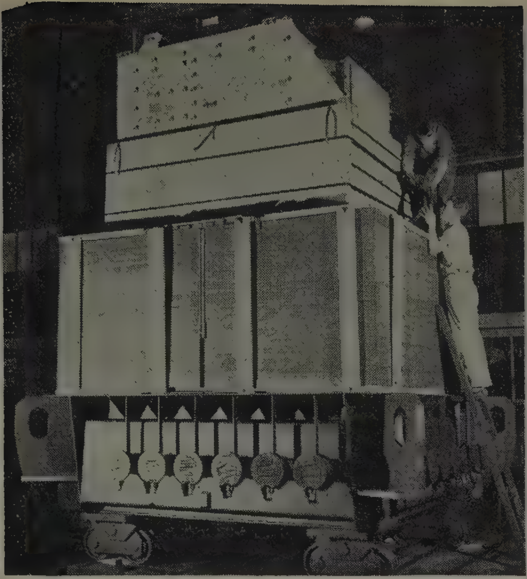
Westinghouse

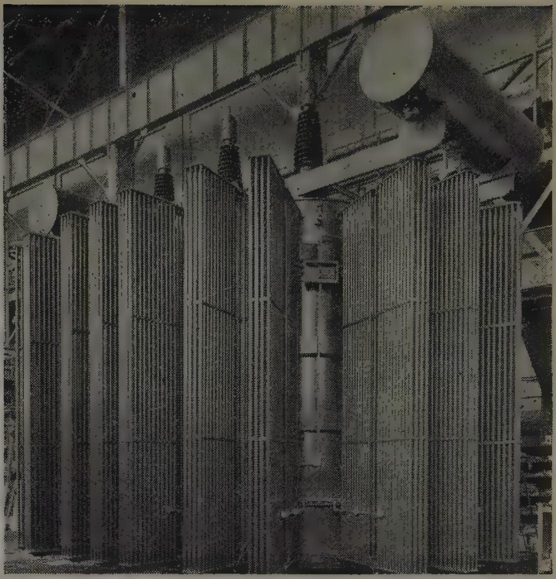


Westinghouse

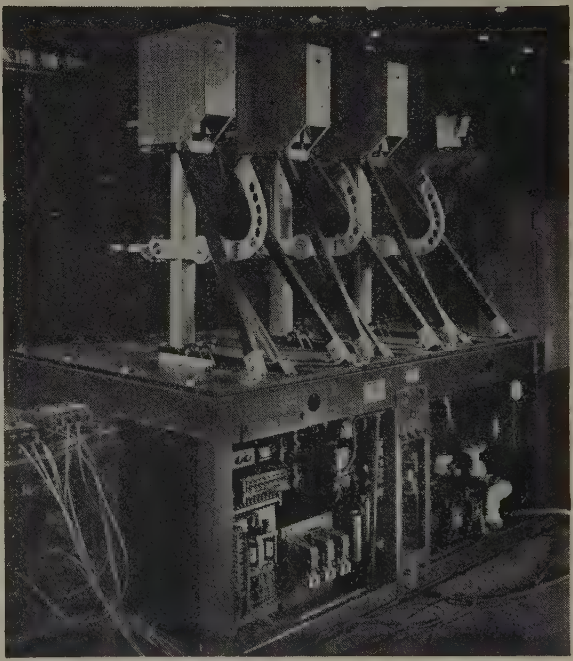
▲ War-born developments kept creating or accelerating new applications last year, especially in transformers. Hipersil cores, glass, silicone, and other insulations that permit operation at 225 degrees centigrade, and air-cooling with special ventilated-coil construction made the construction of small lightweight, high capacity aircraft transformers possible. Typical of these is this 11-kva 3-phase 2-winding unit used for aircraft window heating systems. It weighs only 16 pounds

Westinghouse


Westinghouse


General Electric

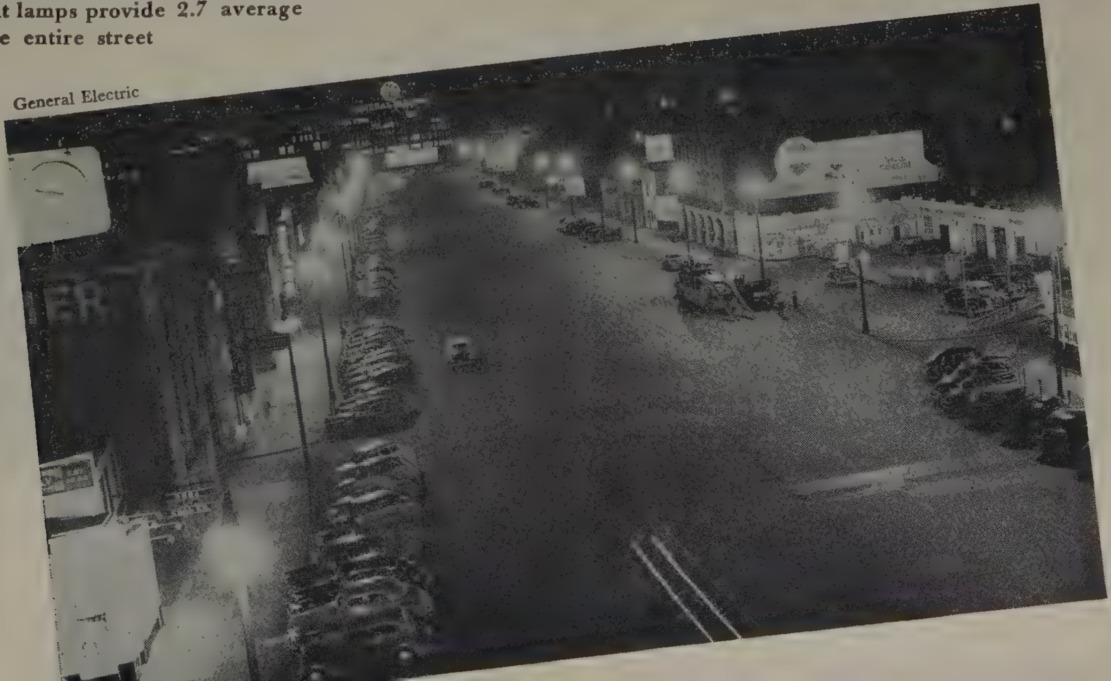
▲ Nonaircraft transformers were improved also. (Left) Newly developed circuit breakers permitted raising capacities of self-protected distribution transformers. (Center) Hipersil cores, shell-form construction, and a form fit tank reduced the size and weight of this 50,000-kva 306,000-pound Bonneville unit. (Right) A large commercial transformer built during the year, this 60,000/75,000-kva 132,000/13,500-volt Y-connected grounded-neutral unit was partially disassembled for shipment

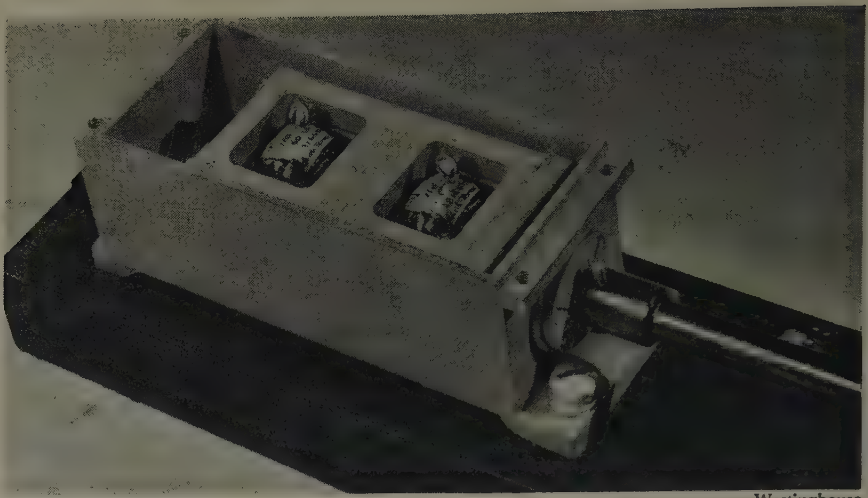


▶ Design specialization resulted in this new Westinghouse circuit breaker for operating duty only to provide maximum service with minimum maintenance

▼ A good example of street lighting development is the installation on Erie Boulevard in Schenectady, N. Y., where 82 luminaires on twin standards in a plane parallel to the curb line using 15,000-lumen filament lamps provide 2.7 average foot-candles over the entire street

General Electric

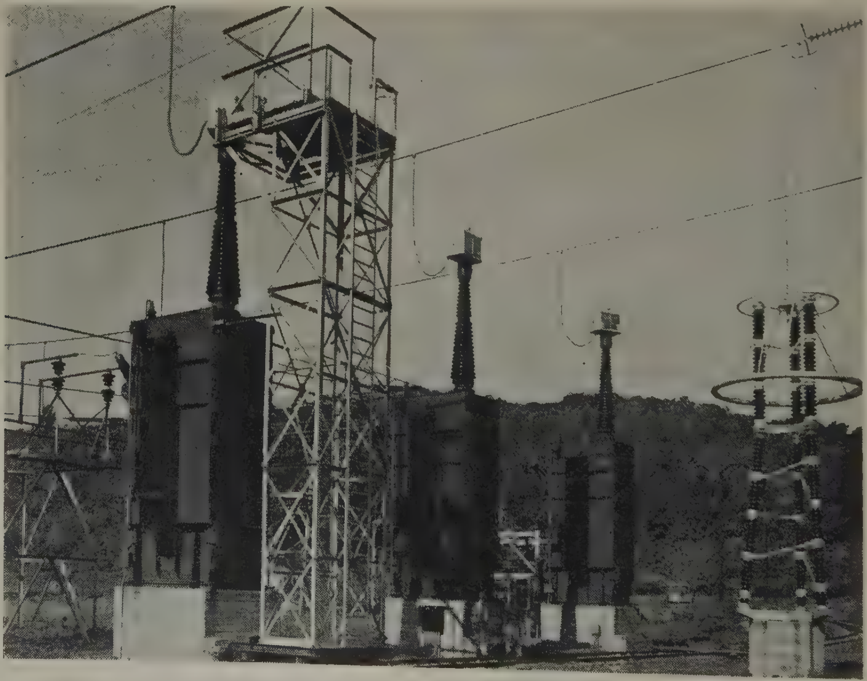




Westinghouse

▲ Strain gauges found new uses in 1947. This magnetic-type unit, mounted on the long boom of cranes like those used in railroad yards, warns the operator when overloads occur by flashing a light or ringing a bell, preventing tipping of the crane

◀ Nickel plating on a steel strip without the use of electric current was a development reported by the National Bureau of Standards. This process, known as electroless plating, produces high-purity adherent coating of nickel or cobalt on metal surfaces. The equipment, consisting of a glass vessel, solution, and immersion heater (projecting from the bath), is simpler and more easily set up than that required for electroplating

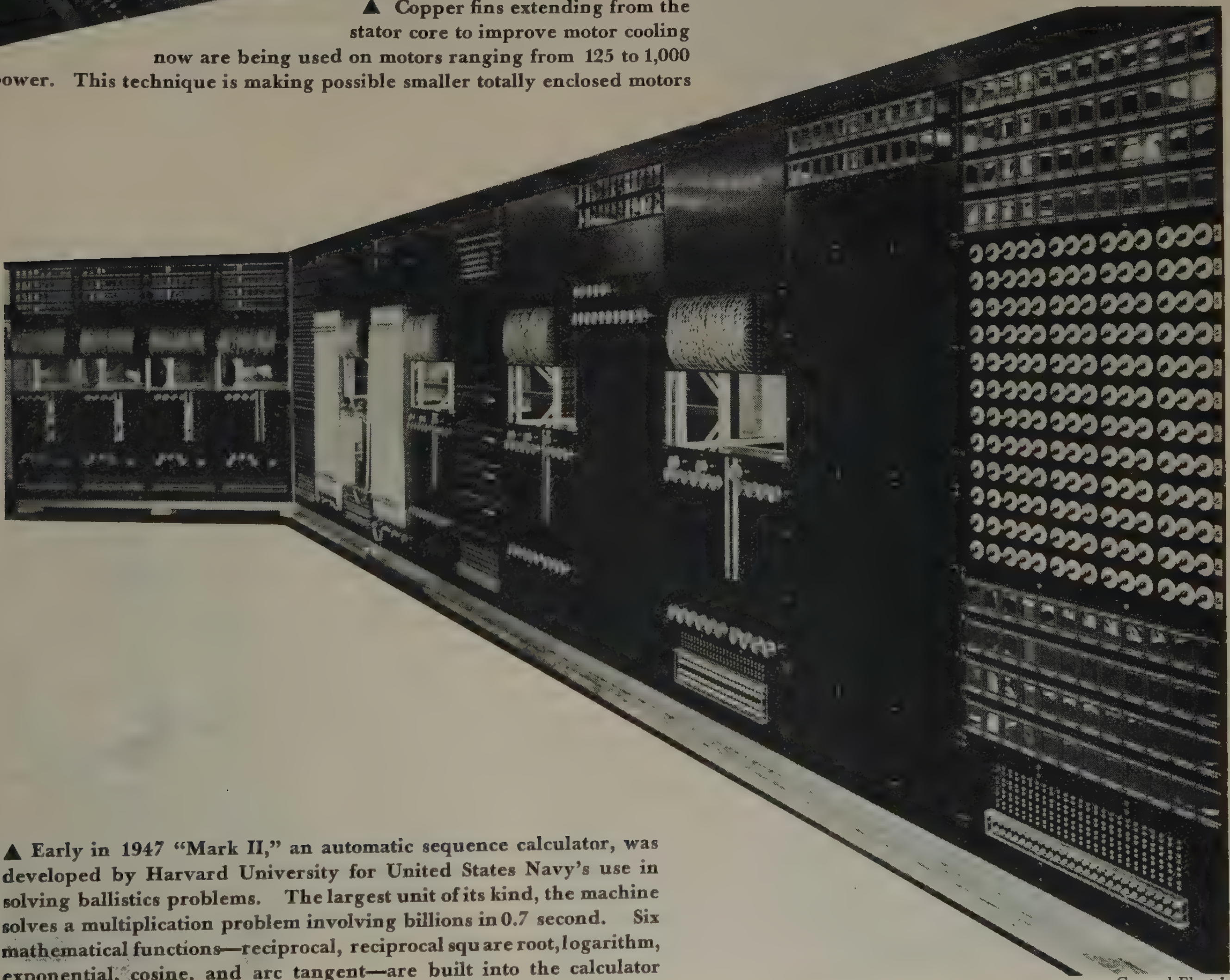


▶ Opening of the 500-kv Tidd test transmission line to study extra-high-voltage transmission problems marked a major 1947 electrical engineering development. Shown are the 5,000-kva transformer bank with measuring instruments mounted in the housings on top of the transformer bushings and the self-supported 350-kv lightning arrester. The movable platform at the left center is for servicing the measuring instruments

Westinghouse

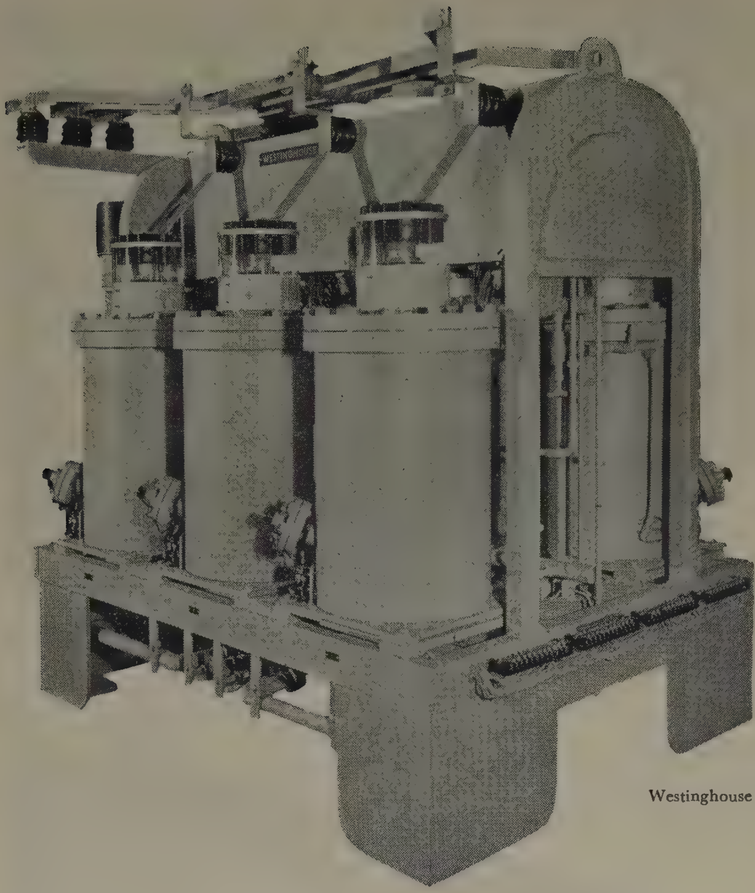
▲ Copper fins extending from the stator core to improve motor cooling now are being used on motors ranging from 125 to 1,000 orsepower. This technique is making possible smaller totally enclosed motors

▲ A camera having a speed of a millionth of a second, developed by General Electric Company, Schenectady, N. Y., is a useful new tool. It is employed in surge testing power generating and transmission apparatus

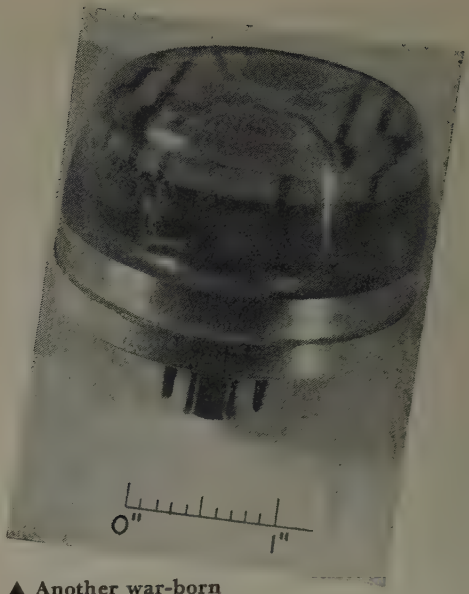


▲ Early in 1947 "Mark II," an automatic sequence calculator, was developed by Harvard University for United States Navy's use in solving ballistics problems. The largest unit of its kind, the machine solves a multiplication problem involving billions in 0.7 second. Six mathematical functions—reciprocal, reciprocal square root, logarithm, exponential, cosine, and arc tangent—are built into the calculator

General Electric


Westinghouse

▲ Continuously-pumped Westinghouse ignitron voltage ratings were increased about fourfold in 1947. This unit is rated at 1,500 volts

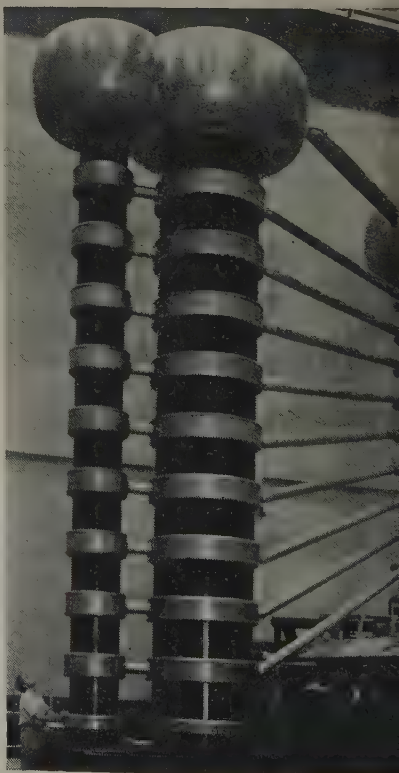


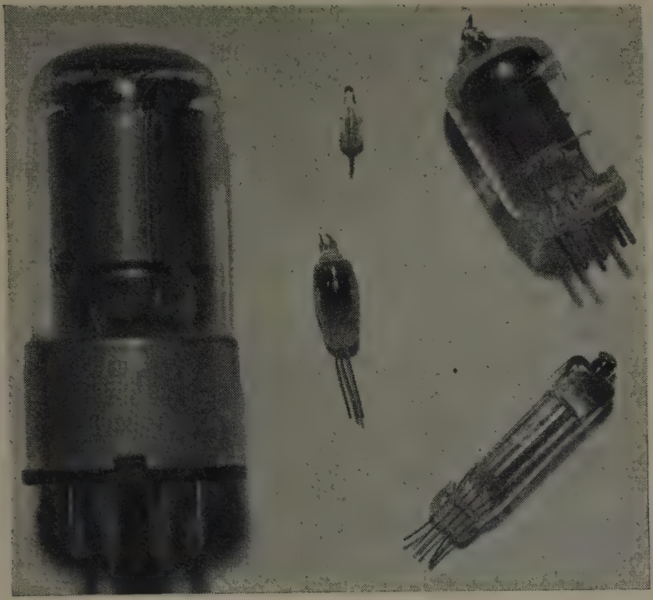
▲ Another war-born development reported last year is the NBS casting resin developed by the National Bureau of Standards. This resin, which provides the required mechanical-electrical insulation for circuits, is particularly well suited for use with subminiature electronic equipment. Such an application is shown here, the device being a plug-in multistage unit potted in National Bureau of Standards casting resin

General Electric

◀ Television relay links appeared in increasing numbers last year. This is one of the towers in the 4-link microwave relay system between New York City and WRGB in Schenectady, N. Y.

▶ The National Bureau of Standards started an X-ray protection program last year to determine the optimum thickness of concrete for use as radiation barrier. The generator, encased in the central column, can deliver an X-ray excitation current of 25 milliamperes at 1,400,000 volts. The smaller column to the left contains a volt meter, and the column on the extreme right is one of three X-ray tubes used for standardizing dosage meters and for exploratory work and co-operative studies with the National Cancer Institute. The radiation pit in which the X-ray penetration measurements are made is located 20 feet below the target of the X-ray tube

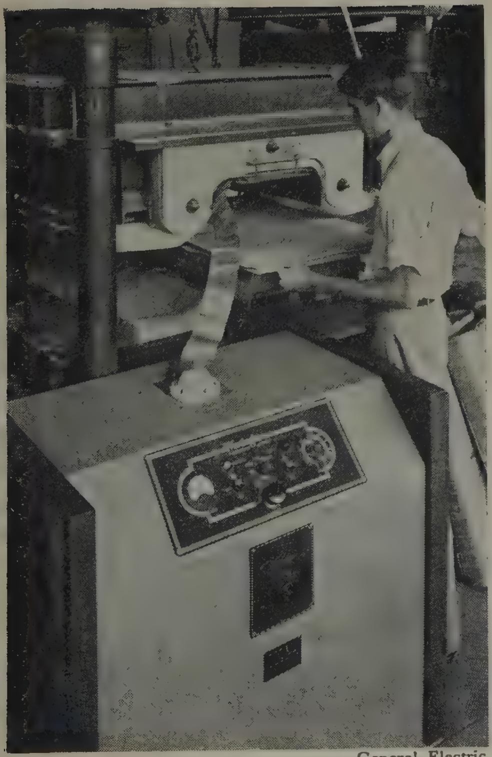




▲ The "microtube" (right, center), developed by the tube laboratory of the National Bureau of Standards, illustrates the degree of vacuum tube miniaturization achieved last year. This tube is compared here with a bantam tube (top), a hearing aid subminiature tube (bottom left), a miniature tube (bottom right), and what was the smallest subminiature tube (center left)

General Electric

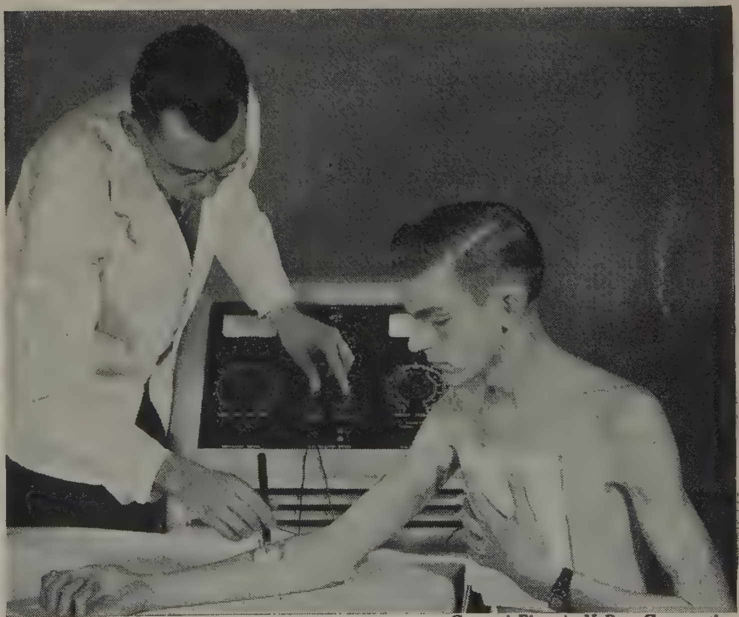
▲ The mass spectrometer, originally a laboratory instrument, found increasing commercial use last year. A process control spectrometer for monitoring and controlling a process by automatic periodic sampling was developed. Shown here is a leak detector, another form of mass spectrometer sensitive only to helium, that is being used on a refrigerator production line to test the piping system for leaks. A section of the system is blanketed with helium and then the gasses flowing in the pipe are tested in order to determine the helium content



General Electric

▲ In plants in many industries radio-frequency heating became an accepted production tool in 1947

▼ An interesting electro-medical development is a variable-frequency sine wave generator known as a "muscle stimulator" which is used to retard atrophy in denervated paralyzed muscles. The unit's output which can be varied from two cycles per minute to 100 cycles per second produces vigorous muscle response at low current intensities that can be tolerated by young children



General Electric X-Ray Corporation

Electronics Comes of Age

L. V. BERKNER
FELLOW AIEE

JUST 50 years ago, in the year 1897, Professor J. J. Thomson made the pronouncement, based on clear-cut experimental evidence, of the separate existence of elementary negatively charged particles—electrons. It was in the same year that Guglielmo Marconi succeeded in radio transmission across the Bristol Channel, a distance of nine miles. These events, in a tangible way, highlighted the foundations on which electronics was to be erected: namely, the elementary particles upon which it is based and the external forces or fields produced by these particles in motion. The phenomenal developments in electronics in the intervening years mark the emergence of the science and the associated nation-wide industry of electronics with all the privileges and responsibilities which go with maturity, privileges and responsibilities which have been acquired with growth and expansion

ROLE OF ELECTRONICS

In every aspect of the basic sciences, we find electronics playing a significant part, either directly or as the catalyst whose presence makes scientific advance feasible. The physicist devises electronic circuits as his "eyes" delve into the nucleus. The chemist deals with electronics in his study of the atom and its valences, of photochemistry, and of a hundred other chemical phenomena. The vista of the geophysicist is enhanced enormously by the tools of electronics in his study of the earth's crust, its interior, and its atmosphere. Until recent times the astronomer could view the sun and the stars in only one octave of light. Now, turning to the broader potentialities of electronics, he can see them over many octaves of electromagnetic radiation. Similarly, the medical sciences have acquired a powerful new tool in the electron microscope, a tool which is of equal importance to the metallurgist. In fact, this one element of electronics, electron microscopy, is itself emerging as a whole new branch of science.

Electronics, then, serves as a common meeting ground of all the sciences in their reliance upon its applications and devices. The constant references to phases of electronics in the scientific journals attest to this common dependence. But just as science in general is dependent on electronics, so is electronics dependent on science for its growth and nourishment. It is in this symbiotic relationship that the responsibility for regeneration arises.

The men of electronics are an especially privileged group, because they have the opportunity to join intimately in developments of all of the sciences. The electronics art, and the industry erected upon it, have a distinguished heritage of science and invention. From the general body of organized science and invention there have emerged during the past century and a quarter the men whose work has contributed significantly and directly to the building of electronics, men such as Faraday, Henry, Maxwell, Bell, Edison, Hertz, J. J. Thomson, Marconi, Lorentz, Braun, and de Forest.

However, as always, with privilege goes responsibility. The men of electronics are expected to derive from their cultural inheritance, and from their association with the development of all the sciences, new creative impulses and a freshness in point of view which will ensure the constant vigor and growth in the field of electronics that are so essential to both science and industry as a whole.

A DEFINITION

What is electronics? It is perhaps too bold to offer any concise definition for such a diverse science, but one can say that electronics is the science that deals with the motion of electrically charged particles in a field of force and with the forces or fields developed by such particles as a consequence of their motion. Similarly, the electronics industry is that branch of industry (primarily) dependent upon electronic phenomena.

Of course, the scope, implications, and potentialities of a science and industry so simply defined are extraordinary. Especially striking is the facility with which the advances in electronic science have been translated, through a virile industry, to applications of great benefit to mankind. But there are still many, many unsolved problems of vital importance for which electronics seems to offer a solution. Can the science and industry continue to meet this challenge adequately? Can electronics continue its growth in maturity to achieve the untold promise which some hold for it, or will it, like Buridan's ass in the debate of the medieval scholastics, come to rest by a balance of internal motivations and propulsions?

BACKGROUND

It has been said that the daily mode of life of our grandfathers was closer to the days of Julius Caesar

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Esentially full text of a paper presented at the Third National Electronics Conference, Chicago, Ill., November 3–7, 1947.

L. V. Berkner is chairman, section o fexploratory geophysics of the atmosphere department of terrestrial magnetism, Carnegie Institution of Washington, Washington, D. C.

Since the discovery of the electron, just 50 years ago, electronics has emerged as a full-fledged science and industry. However, with maturity, also has come new responsibilities for creative vision and enterprise. Whether the challenge can be met is dependent upon whether research and industrial groups can be integrated to provide the necessary initiative and support.

than to our own. To see this in a scale of history, we recall that written history has an age of perhaps 300 generations; so that our life span is about one per cent of this. The industrial revolution has taken place in the last ten of the 100 generations of the Christian era.

Until about 200 years ago the development of industry substantially was related to the simple ideas, ideas which were readily apparent to the relatively untrained. Transportation and communication depended wholly on the beast of burden (including the natural propulsive power of man) or on the wind. Light and heat depended directly upon the sun or fire. It is true that there were certain exceptions such as the manufacture of gunpowder, which stemmed from alchemy, the father of chemistry; but, on the whole, industry was nurtured on ideas which depended on the day-to-day experience of the average man.

Then suddenly there emerged a number of new industries drawn from a new source—a foundation of science and philosophy so complex that even the need for each new industry produced was undreamed of a few years before. In the history of cultural development, this new-found ability to control complex phenomena and turn them to useful ends on a society-wide scale by precise observation and clear generalization through the processes of logic seems comparable only to the development of man's ability to transfer ideas through combinations of written words. These new industries were not only mutually supporting, but they supplied the means from which others could grow. Even more important, they provided the tools which gave the scientist more convenient access to the limits of knowledge, permitting him to extend these limits at an ever-increasing rate. In turn, the knowledge so acquired again generated and developed industry. In brief, tools make tools.

This process is a truly regenerative one. It is this interaction of regenerative form between science and industry which has brought about the astounding progress of the past ten generations. In common with regenerative circuits, however, such progress can continue only when no saturation or limitation arises in any part of the circuit; and already in electronics there are signs of saturation in unexpected places. Redesign of the critical parts to higher limits for the benefit of the whole of society is a challenge to the ingenuity of the engineer and industrialist.

In an examination of these potential limits, one should turn first to the requirements for research and development. Research can be defined as theoretical analysis, exploration, and experimentation, without completely defined goals, directed to the increase of knowledge and with it the power to control phenomena. Development is the extension of the investigative findings and theories of a scientific or technical nature into practical application for experiment or demonstration purposes including construction and testing of experimental models.

The generality of these definitions should be emphasized. Often development is mistaken for research. A laboratory devoted to development alone tends to degenerate quickly and to lose contact with the boundaries of knowledge, and it is from these boundaries that the more useful ideas often are drawn. The laboratory must have experimentalists who critically and analytically observe aspects of natural phenomena to disclose and classify their true nature, thus bringing to light new knowledge. It must have theoreticians who, through exact application of logic to our knowledge of natural events, can generalize and infer the ultimate consequences, thereby extending and predicting the potential boundaries of observation and application. It must have engineers of bold imagination and vision who can mold useful ideas into products or application of sheer artistry in concept and design. Finally, as these men and processes together can generate new ideas and applications, they must work in an atmosphere of freedom which encourages fruitful thought and achievement, and effective translation of ideas into form for the general benefit of society.

It is clear that, for our system to be truly regenerative, there must be ample and amply trained minds, skilled, possessed of initiative, and capable of original, creative thought. Equally true, there must be opportunity for these minds to initiate and to create. This means that there must be facilities commensurate in quality and supply with the minds that are ready to use them. The opportunity that is offered in a free society is an index of the power that will arise to utilize it. American higher education has demonstrated that, given proper opportunity, it readily can account for the requisite advanced training. Industry can, and does in many instances, share fully in the provision of opportunity for that training to be put to use. In a progressive and advancing society, the need for expanding opportunity does not cease. On the contrary, it increases, and hence it is essential that industry be ready to go beyond the levels thus far reached, and make available more widely and more freely the facilities vitally needed for the proper pursuit of research on which industry itself depends. Thus two ends will be served—the one, the maintenance of research as an essential component of our society; the other, the continuing vitalization and expansion of industry through the opportunities opened up by research.

It is interesting to see that our forefathers understood these needs in an implicit sort of way. Even when they were hewing their future out of the virgin land, they were taxing their hard-earned resources to establish the colleges and universities which have played so large a part in the development of the United States. They understood that the future welfare of the community depended upon the extension and improvement of its culture and technology.

RESEARCH A COMMUNITY AFFAIR

The existence of a sound and adequate research and development effort is of interest not only to the scientist, the engineer, or the director of industry, but it is a community affair. Its benefit is measured not alone in terms of the employment of its research scientists and engineers. A hundred times more important is the genesis of new industry and of the cultural and material advantages which flow from its presence. It has been said that each research worker guarantees the employment of 20 men. To reap this benefit, the community and its industry must take an active part in the establishment of facilities for science adequate for its own welfare. There are literally dozens of examples where whole communities have risen on the support of a few men of science and invention. The future welfare of these communities depends on continued exploitation of knowledge at a rate adequate to maintain and to increase employment by production of acceptable products, for progress implies change.

Progress in modern industry is dependent upon adequate research and development. Industry readily must comprehend the most advanced ideas and add its own creative artistry to maintain its pre-eminence, When some artificial economic or political factor interferes with its normal production, it must be ready to create new and effective offshoots. Ability to change requires "know-how" within the community, a real comprehension of things as they are and as they potentially could be. As electronics is one of the essential elements of so much of science and industry, creative electronics research is an important necessity to a progressive future.

During the past war a group of electronics manufacturers from the Chicago area asked for a conference with the Secretary of the Navy. They pointed out that they had enormous factory capacity, a good source of labor, and plenty of machinery. They were anxious to throw more of their facilities into the war effort. But the bulk of new electronics business was going to firms in the East! Why?

There was tremendous evolution in application and form of electronic equipment during the war. This was not a matter of whim—it was the result of the need to meet and forestall the evolution of enemy tactics. The source of this new equipment was the laboratory where the scientist and engineer joined with the tactician and strategist to devise the most effective means of combating each new or anticipated tactic. It was a matter of necessity, then, that the Army and Navy turn to organizations whose research and development laboratories had the capacity, quality, and vigor to provide the solutions needed, and usually the production contracts followed. Unfortunately for the equitable geographic distribution of such contracts, the majority of adequate industrial electronic laboratory facilities were at that time in the East.

Here, then, is a specific example where the life of a community was affected adversely by a shortage in research and development. Here is an example of saturation in our regenerative system of progressive industry. Continued growth and welfare depend importantly on renewal and expansion of industry through constant generation and advance of ideas. It behooves the engineer, the businessman, and the financier each to protect his industry and his community, in proportion to his business and investment, with the safeguards of creative thinking evolved by research and invention. Support of research is an economic matter required for the welfare of the industry. But it is also a cultural matter deserving the support of the whole community. Its planning requires initiative and effort from the financier, the educator, the professional man, and the merchant alike. Here is needed the same kind of foresight demonstrated by the pioneers who taxed themselves under the most adverse conditions to establish our universities.

NEED FOR GREAT SYSTEMS

There is yet a further challenge which the electronics profession and industry face as electronics comes of age, the challenge to produce great systems which will meet needs of vital importance to the economic welfare and security of the United States. This challenge is a real test of the industry's maturity.

During its growing or formative years, the electronics industry has done notable work in devising systems, radio transmitting and receiving systems, simple radar systems, and the like. Traditionally, systems have been provided from the research and development laboratories of industry and, more recently, from those of the universities, also. In the laboratory, the scientist and engineer draw the general requirements for system performance in the light of advanced potentialities and then proceed to draw the general plans for design and performance of the elements of the system. Then are required the research, the development, and the engineering to produce these elements, each of which must meet a specified minimum of performance, so that it successfully may contribute its required part in the integrated system. Finally, the elements are assembled one by one into the system, which is tested as a unit. Here adjustments and compromises are made in the light of the experience acquired in the building of each element, experience which translates the design estimates into reality of over-all performance.

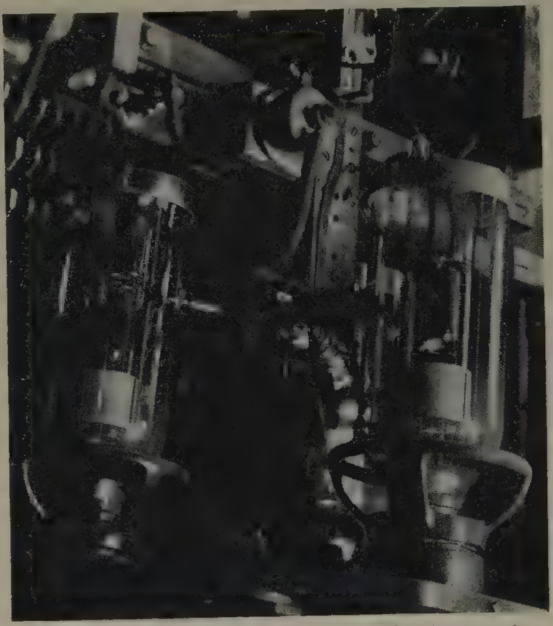
The systems engineering of early television is an outstanding example.[1] Under the leadership of Doctor Herbert E. Ives, the broad design of an achievable television system was laid down in light of the most advanced theoretical and instrumental limitations of the time. Then parts were "farmed out" to qualified groups of the Bell Telephone Laboratories. Where doubt existed as to the feasibility of a critical element of the system, more than one approach to a solution was initiated. This approach also provided for the ultimate comparison of the efficacy of alternate designs. The efficiency of this method was demonstrated by the outstanding success of the Washington–New York television transmission in 1927 by both radio and wire-line.

This pattern for systems engineering successfully was repeated again and again during the war, where high performance and speed of achievement of new electronic devices or of small electronic systems were critical. Probably the most recent and outstanding example was in the production of the atomic bomb in which electronics has played an important role.

These are examples where the industry has been outstandingly successful in producing systems within the capacity of the existing industrial organization. But these very successes have generated the need for even greater contributions. Reasoning from past performance, society confidently expects them. For instance, consider the fields of air navigation and freight dispatching. It is reasonable to expect that the problems in both areas should yield to systems solutions predominantly electronic in nature.

There have been tremendous strides towards solution of individual elements of the problem of air navigation: the ILS (instrument landing system) of the Civil Aeronautics Authority; the GCA (ground-control approach); multichannel very-high-frequency communication; and a dozen others of equal or greater importance. Many applicable elements have been created without their application to air navigation being realized immediately. Nevertheless, one may question whether a really satisfactory system is in sight, despite the fact that many believe that the elements of a satisfactory system are at hand or achievable under a properly organized systems attack. While the present situation is difficult, the future promises a still greater challenge when higher speed aircraft with lower fuel reserve, counted in minutes, will be coming into use.

This is an example of a really big systems problem for it must be conceived and operated on a national scale. The welfare and future development of whole industries depend upon its satisfactory solution. It is this kind of responsibility which electronics must face as it arrives at maturity. Have we evolved the means for meeting such problems and on a reasonable time scale?


Westinghouse photo

"... as electronics comes of age its future is bright..."

THE COMMITTEE PROCEDURE

When problems of national scope arise, they often extend beyond the resources of a single corporation. Accordingly, the committee procedure has been evolved. The committee can bring together the diverse points of view representing different aspects of the problem to ensure that each significant facet is considered; it can recognize the feasibility of a solution or solutions along generalized lines; it can determine the probable limitations on the several solutions; and it can advocate the means whereby the problem can be formulated in detail and the solution processed.

Because the committee idea is so effective, common sense demands that we do not abuse and vitiate it by superimposing operating functions upon it. It is easy and inviting to ask the committee to recommend or to produce the form of the systems solution, but we must look beyond the committee step. What, then, are the requirements which must be fulfilled in devising and achieving a systems solution to new and great problems?

First, the processing of a systems solution requires centralized responsibility and authority to make decisions, that is, in the sense of financial and product responsibility. Second, the systems solution requires centralized technical direction of a caliber in proportion to the importance of the problem. Third, the systems problem must be digested by the experimentalist, theoretician, and engineer collaborating in the laboratory so that they may produce an advanced and creative foundation on which the detailed solution is conceived. Fourth, the detailed systems solution can be formulated only in the laboratory where potential performance and feasibility of any idea or device can be tested and assessed finally and authoritatively by the men most qualified to do so with the necessary facilities at hand. Fifth, the system must be assembled, and the final compromises or substitutions made, after the realizable performance of each element has been assessed, by the men responsible for the systems design and the elements thereof, and, above all, responsible for its ultimate performance. Sixth, the system must be tested thoroughly in part and in whole under the control of the designers on an adequate test range as a part or reasonable facsimile of the operation for which the system is designed. Finally, but by no means last, there must be a powerful incentive to early achievement such as national security or the profit motive.

Other groups have faced similar problems with large systems, and a brief examination of their approaches should be profitable.

An outstanding example is the telephone industry, which represents a specialized field of electronics and which has evolved into a monopoly under government sanction and regulation. The need for this monopoly or its efficacy to provide nation-wide telephone communication seldom is questioned in view of its effectiveness and its extent when compared with the systems of any other nation. The telephone industry, supported by tremendous laboratory facilities, is evolving its system design within the nation-wide operating network.

A second example is the electric power industry. As the need for systems engineering arose in the early history of the industry, consulting engineering firms were organized to design the systems. But as the size of the systems grew, the equipment industry was integrated into larger units proportional to the size of their problems and the systems engineering gradually was taken over by the whole industry itself through close collaboration between the manufacturer and the customer for the systems, which were the public utilities. The original consulting firms veered off to the field of construction and operation.

A third example is the engineering and construction of the Hoover Dam. No single company was willing to assume this enormous undertaking, so that no bids were received until the organization of the "six companies" composed of the largest engineering and construction companies in the field. With their combined resources, the job was done quickly and superbly.

NEED FOR INTEGRATION

The examples cited seem to demonstrate two things, first, that industry can do a big new systems job if properly organized and, second, that it must integrate when the size of the job to be done exceeds the resources of its individual elements. This is the real crux of the matter. To face constructively the great systems problems which have come about with the attainment of maturity the electronics industry must take the necessary steps to mobilize its brains, its facilities, and its manpower, and to bring together the individual components required for an admirable solution, all within free enterprise, to get each job done.

Unquestionably, such an evolution in organization will pose a number of patent problems. It is important that the integrity of our patent system be preserved so that development and invention receive the encouragement and support needed by a progressive nation. But to retain these advantages, particularly when organizing for great systems problems, industry must take the initiative to gain the fullest value implicit in the American tradition. It is doubtful whether any one company holds the patents necessary to the solution of our greatest electronics systems problems. This fact may lead to awkward and artificial solutions built around patents held by individual industrial groups, and often the offering of a number of equally awkward and inadequate solutions by competing groups. The joining of these ideas and devices to meet a specific problem greatly would enhance the probability and effectiveness of solution.

There are several ways to meet this issue. For example, a plan of full participation—an open pool of electronic patents—might be formed under the auspices of an industry committee which determines fair, yet stimulating, royalties with the privilege of appeal to the courts in event of dispute. This specific proposal is not important within itself, nor, in fact, is any individual plan for implementation. The important point is that industry itself should take the initiative to create the positive measures needed to marshall its full strength to meet major systems problems and, at the same time, to meet its related responsibilities in maintenance of free enterprise and fair competition.

The "air-navigation" problem was discussed in previous paragraphs, but perhaps in titling this problem the solution has been restricted to less than the national need. For example, we need a constantly improved air-warning network as a measure of national defense. One well might ask whether the air-navigation problem and the air-warning problem are not so closely integrated as to yield to a common solution. Further, one well might ask whether our national economy can support two separate systems, each on an adequate scale.

Here is a real problem for a committee, inasmuch as, first of all, some really basic national issues must be examined critically. In this examination the committee must assemble and evaluate the contributing elements which comprise the whole problem. As a step toward solution, a committee, for example, might recommend the organization of a "six companies" with national sanction, support, and regulation, if this seems an appropriate and effective measure to achieve the desired end. However, a committee should not be overburdened nor its prestige and effectiveness diminished by asking it to assume responsibility for systems planning and design which should be undertaken by a mature industry properly organized to meet this responsibility.

There is a natural tendency to look to the government for the leadership in attacking such problems as these great systems problems so often involve a large part of the national interest. This tendency grew stronger during the war, when systems effort was directed substantially to the service of the Armed Forces. But there is obvious danger in too much dependence of this kind, for often the government is responsive to great needs only after they have become critical. Industry has a real opportunity to point the way by seizing the initiative in recognizing and solving problems before they reach the critical stage. In fact, one might say that the real measure of free enterprise in any nation is its ability to lead the nation to competent and lasting solutions of its great systems problems—solutions from which the nation acquires its pre-eminence and prestige.

PROBLEM OF FREIGHT DISPATCHING

There are other systems problems which, while not of a nature to lead to government interest, are of real significance in shaping the nation's future. Consider the problems of the movement of freight. Generally, upon starting a freight shipment, no one knows exactly where that shipment is until it arrives at the marshalling yard at its destination. There are, of course, some exceptions, but these are not the rule. Undoubtedly, no one is more keenly aware of this problem than the railways themselves. But the railways cannot be intimately aware of the potentialities of electronics which could be brought to bear on this problem. Nor can the electronics industry alone fully appreciate the problems of freight handling and freight dispatching which the railways presently face. Nevertheless, one could imagine a national system of freight dispatching and routing, largely electronic in nature, to provide freight movement by the most expeditious route and to provide more uniform loading in our transportation system. Such a systems development should make a substantial improvement in our economy and therefore should be profitable to both railroad and customer. In fact, a comprehensive system might embrace all forms of freight handling.

This example of the need for freight dispatching systems is representative of a whole group of great systems in which electronics can undertake a vital role. They are often systems which involve the integration of the "know-how" of a few or of many industries and the organization of essential elements of each to meet fully the responsibilities that are entailed by the problem. Since electronics has come of age, it should assume the initiative in encouraging its peculiar solutions and in organizing to effectuate these solutions, and it must be prepared to join hands with other industries to do the job. The nature of joint responsibility is much the same as that which has developed in the electrical industry where the manufacturer and the customer industries have joined to produce the advance.

The discussion, thus far, has considered the question "How can a great system be designed, how can its elements be integrated into a working system which will meet the diverse requirements when operated on a national scale?" A corollary question also must be raised: "How can this integration be effectuated, so that the old is absorbed in the new with no loss in ultimate effectiveness?" While the question cannot be answered here, it raises a point worthy of emphasis.

We often hear of "revolutionary ideas," but it is difficult to conceive the reality of a situation in which we change from the old to the new in a day, a month, or even a year. Revolution from one system to another is blocked by many things; by existing investment, by difficulties of production, by cost of carrying the investment of components of the revolutionary system until a fictitious "R" day, by installation time, and, more important than all of these, by the necessity for training of thousands of personnel who must learn to operate the new system with reasonable precision to make it effective. Our society and economy will not permit retrogression of performance, even when it may seem to some a desirable step in transition toward superior performance in the future. The progress to new systems must be conceived as steps in evolution, not as a revolution—an additional heavy load on the systems designer.

The creation of the really large and important things of the future, those things which require extensive systems thinking and development, is dependent on adequate initiative and support by sufficiently integrated research and industrial groups. In a country where private enterprise is dominant, it should take the lead. In fact, the measure of free enterprise is its ability to exercise this leadership.

This is a real challenge. Industry must not look to the government to tell its engineers what to do next but should produce, on its own initiative, solutions which are so adequate, so elegant, and so impelling that the nation is led by sheer force of logic to their adoption. Its members must get together honestly to pool their brains and resources to the extent required by the job, recognizing that congressional sanction and government regulation may be an eventuality because of the national scope of the problems. It must recognize and frame its problems clearly, and it must provide sound solutions which will be of the greatest benefit to society. This is still possible for research and industry in the United States.

It would seem, then, that as electronics comes of age, its future is bright and its potentialities unlimited if it meets these responsibilities for constant self-renewal and for the creative vision, enterprise, and initiative which always have characterized American industry.

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Some Experiments in Frictional Electricity

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MEMBER AIEE

For several years data have been collected on electrostatic effects at low humidities. Sufficiently consistent results have been obtained to make the studies valuable to the cotton processing and textile industries.

THE results of studies at Texas Technological College, Lubbock, Tex., and at the University of Texas, Austin, Tex., of electrostatic effects common to regions of low humidity, are illustrated by means of curves and tables in this article. In common with the experience of other experimenters in this field it was found that data taken at different times, under apparently identical conditions, did not always repeat exactly, but a number of causes for this discouraging feature eventually were isolated and within a specified range a reasonable consistency in the data exists.

The study began, in a general way, with an attempt to obtain numerical measurements of electrostatic potentials generated in rotating machines under various conditions of speed, temperature, and humidity. The relation of contact electromotive force to the possible electron displacement per unit area of surface and the combination of materials resulting in minimum and maximum charges arising from these displacements were studied.

After some observations on belt-driven machines and other sources of electrostatic charges in industry, a small rather simple apparatus was constructed in which different conditions of operation could be simulated and the effects studied. The object of the apparatus (Figure 1) was to provide two frictional surfaces of approximately equal area so that electrostatically aiding and opposing combinations of materials could be compared either by means of a measurement of the average current, or by means of the charge impressed on an electrostatic voltmeter. The common material producing the friction was cotton, while the contact electrodes were various materials in common use. The rotating member is a stack of annular cotton disks, which, when firmly held together by two polystyrene flanges, provided a rubbing surface one centimeter in thickness. The sample materials were held against opposite diameters of this "buffer" and mounted so the pressure readily could be adjusted. This pressure was not measured but was found to have a critical value at which the greatest rate of electron flow took place. The samples were mounted on convenient pieces of plywood, these pieces in turn being held by polystyrene standards and well insulated from the base. The speed of rotation was measured with a stroboscopic tachometer.

After tests were made using many of the more common materials included in tables of the Tribo-Electric Series, a number were compared against silver as the common electrode; the results are plotted in Figure 2. In this connection, it was found that certain highly-insulating materials such as glass, although capable of high degrees of electrification, could not supply a sufficient number of electrons to indicate charge on the voltmeters. Measurements on these were made employing a Zeleny electrometer. These tests showed that polystyrene would be the best insulating material for use in the construction of the apparatus of Figure 1. In these tests, the vacuum tube voltmeter was used. The relatively low internal resistance of the vacuum tube voltmeter as compared with the resistance of the cotton rotor reduced the effect of the shunt leakage path and gave results more nearly independent of humidity conditions.

The operation of the apparatus employing the electrostatic voltmeter first will be considered. The transfer of electrons across the contact surfaces, as it depends only on contact potentials, should remain constant at a constant speed of rotation. This results in a constant current being fed to the voltmeter with the rotor itself acting as a shunt leakage path. Let

I = total current flow attributable to transferred electrostatic charges
I_r = leakage current in amperes
I_c = voltmeter charging current
C = capacitance of voltmeter
R = resistance of leakage path
V_c = voltmeter reading

Then

$$I_c = I - I_r \tag{1}$$

$$V_c = 1/C \int (I - I_r)\,dt \tag{2}$$

also

$$I_r = V_c/R \tag{3}$$

so that

$$V_c = 1/C \int (I - V_c/R)\,dt \tag{4}$$

Differentiating,

$$\frac{dV_c}{dt} = 1/C(I - V_c/R) \tag{5}$$

Which gives

$$t = RC[\log_\epsilon IR - \log_\epsilon (IR - V_c)] \tag{6}$$

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This is the time in seconds required to charge a known capacitance against a known leakage resistance.

Measurements of the maximum potential reached in this apparatus under various conditions of humidity were made and the results plotted in Figure 3. The equation of the curve based on a number of experimental points taken under different conditions of humidity was found to be

$$Kv=\frac{3.8(80-H)}{H-34.5} \qquad (7)$$

where Kv is the potential difference in kilovolts and H is the relative humidity in per cent. The equation indicates that at 80 per cent humidity, no electrostatic charges will be retained. At humidities near 34.5 per cent, cotton becomes an extremely good insulator and maximum electrostatic potentials may be expected.

The leakage resistance of the rotor was measured under different degrees of humidity by taking "discharge curve" readings after the motor was stopped. Values are tabulated in Table I and the highest value was used as a check point in calculating the kilovolts at 37 per cent humidity. The maximum voltage at this condition was far off the scale of the voltmeter, but a comparison of the JR drop in this instance with the calculated potential difference from equation 7 gave 66 and 65 kv, respectively. Equations 1–4 show that all the current at $t=0$ goes to charge the capacitor, but at maximum voltage, as the same current still is supplied, it all must return through the leakage path so the final voltage equals IR.

Assuming that electrons will cross the surface of two unlike materials during each change of surface in a

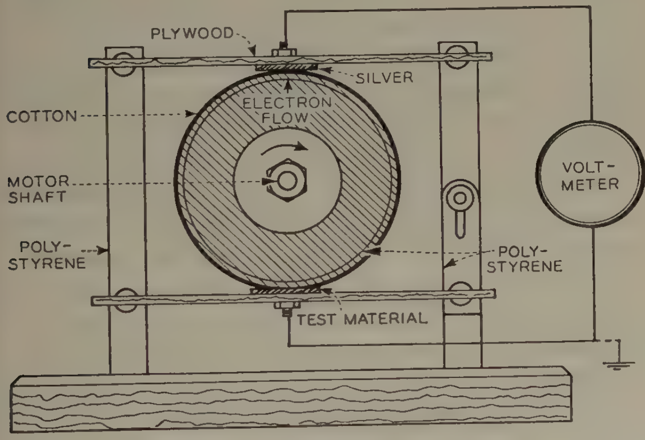

Figure 1. Apparatus used in tests

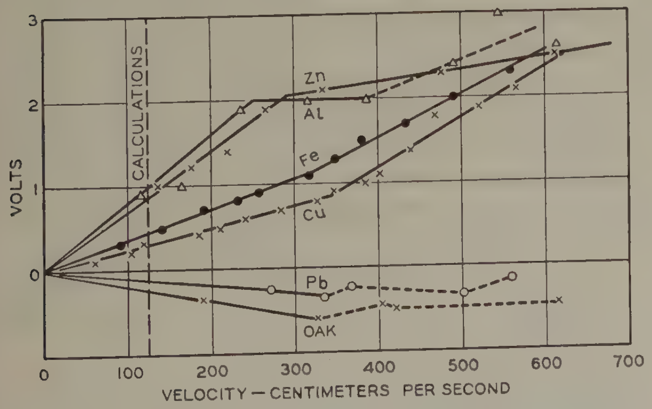

Figure 2. Comparison of materials with silver as the common electrode

Relative humidity—43 per cent

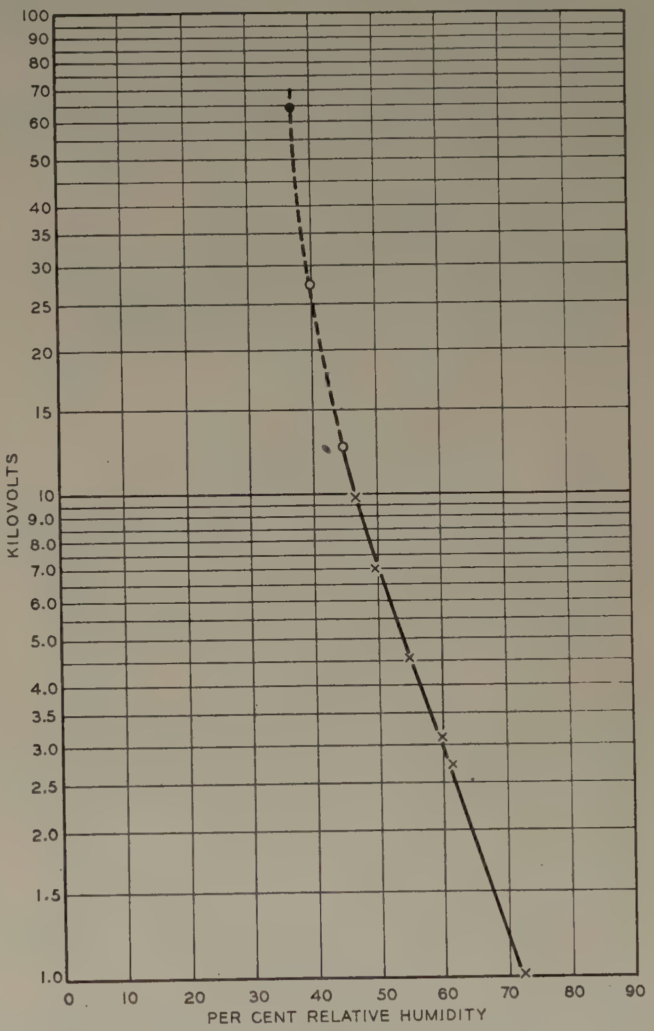

Figure 3. Maximum potential reached under various conditions of relative humidity

×—*Test points*
○—*Equation*
●—*Checked by resistance measurements*

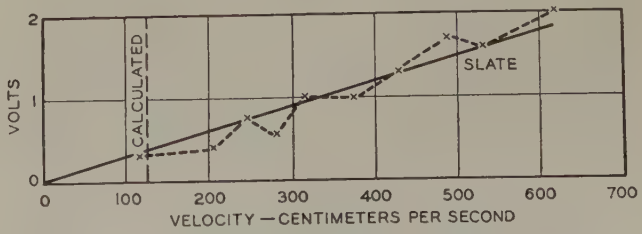

Figure 4. Typical curve using a composite material

Relative humidity—43 per cent

friction device, the active area is equal to twice the contact area.

Choosing the velocity of 125 centimeters per second, the total current flowing through the voltmeter is 0.0965 microampere for the Ag–cotton–Al combination. Neglecting the leakage current which, in this instance passes through a resistance of 1.4×10^{11} ohms acting across a potential difference of 1 volt, the current results from transported electrons from aluminum to silver on the cotton carrier, plus the electrons from contact potential at the silver electrode.

The time required to complete the change of one contact surface is 0.016 second. Thus the electrons flowing during each time of contact would be

$$0.096 \times 10^{-6} \times 6.29 \times 10^{18} \times 0.016 = 9.7 \times 10^{9}$$

The average interchange per square centimeter of active area would be this value divided by eight, for the particular friction areas in this apparatus.

A study of the curves of Figure 2 reveals that a similarity in contact potential ratio exists when these materials are compared with published tables.[1] If a constant value of 0.25 which is partially attributable to the silver-cotton contact is subtracted, values result which compare as shown in Table II. The calculated voltage values as shown do not represent contact potentials as they are dependent on the internal resistance of the vacuum tube voltmeter, but the agreement in ratio is interesting to note and the procedure might lead to a simple method of approximating contact potential values for materials in common use.

Table I. Discharge Curve Readings

Per Cent Humidity	Resistance, Ohms
37	1.55×10^{12}
50.5	1.4×10^{11}
59	1.65×10^{10}

Only the lower portions of the curves of Figure 2 were used in any computations made, as these appear to give sufficiently consistent results on repetition. The discontinuities appearing at the higher speeds have not been accounted for, but in several sets of readings taken on zinc and aluminum, they consistently appear. Recalling the number of outer-shell electrons in these elements, it is interesting to speculate on the possible connection with the changes in slope found. Incidentally, the slope for copper was found to be practically constant in all cases and the deviation in Figure 2 may be the result of erratic data.

The maximum current flow for materials in common use was found to be approximately 0.10 microampere per square centimeter of contact surface at a velocity of 250 centimeters per second. Below this velocity, the current decreased directly with speed. Above this velocity it is probable that the electron transfer would take place at a slower rate resulting in one or more lesser slopes for materials having more than one outer-shell electron. These values should hold for untreated cotton belts and other cotton-to-metal contact or friction areas.

Table II. Comparison of Standard Values of Contact Potential With Those Obtained by Experiment

Smithsonian Institute Values Base = Ag	Material	Calculated from Figure 2 Base = Cotton
	Oak	−0.48
	Pb	−0.37
0.00	Ag	
	Cotton	0.00
0.05	Cu	0.05
0.19	Fe	0.20
0.59	Zn	0.60
0.99	Al	0.75

Humidity is an important factor in charge accumulations as it has a direct bearing on the leakage path. Relative electrification in this respect may be estimated from equation 7 if the potential rise at any one condition is known.

Although other materials, such as glass and hard rubber, may have high contact potentials with metals, for example, the resistance at the contact surfaces may reduce the total number of electrons transferred, so that the resulting accumulated charge is relatively small. However, these materials so may increase the leakage path that the total charge dissipates slowly allowing a high potential difference to accumulate.

It was found possible to build up high potentials even where like materials are employed at opposite extremes of the carrier. This could result from differences in contact area, contact resistance, frictional variations, and impurities. However, in the latter instance, they could not strictly be considered "like" materials.

Undesirable combinations of materials likely to be subjected to high potential differences may be recognized by referring to a table of Tribo-Electric Series.[2] Incidentally, the curves of Figure 2 might explain, to some extent, the note in connection with this table which states in part, ". . . .circumstances may alter the relative positions in the list." It may be observed that the curve for zinc crosses several of the others in the upper ranges of speed. Finally, Figure 4 illustrates the type of curve to be expected from a composite material.

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Voltage Notation Conventions

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A critical analysis of voltage conventions and double subscript notations reveals that great confusion in electrical engineering literature is caused by the lack of uniformity in designating voltages and potential differences. A possible set of standards is offered for consideration.

DOUBLE subscripts appended to the symbols for voltage and current have been used for many years to denote the points between which a voltage or potential difference is measured or between which a current is flowing, and they have proved extremely convenient and useful in facilitating the solution of circuit problems. When applied to currents, the meaning attached to the subscripts and their order have been universally the same, but, when applied to voltages, different conventions are used by various authors. The lack of a uniform practice in this respect had led to confusion and misunderstanding on the part of engineers and, more particularly, of the student who has not adopted a definite system in his own mind. To call attention to this difficulty and to advocate ultimate standardization on the most suitable convention is the purpose of this article. The importance of a clean-cut and well-understood convention will not be minimized by the engineer who has been required to give detailed consideration to the problems of directional relaying, multiwinding transformers, parallel operation of synchronous machines or transformers, feedback in electron tube circuits, and a multitude of similar problems.

In accordance with the standard American Standards Association definition[1], the sign of the potential difference between two points, one of which is taken as a reference point, is positive if work must be expended to transfer positive electricity from the reference point to the other point. In this instance, the second point is described as positive, with respect to the reference point, and the reference point is negative, with respect to the second point. If the sign of the potential difference is negative, the second point becomes negative with respect to the chosen reference point, and the reference point becomes positive with respect to the second point. In this article, the simple term voltage will be used synonymously for potential difference which appears in standard definitions.

If a resistor were connected between the two points or terminals, there would be a positive current directed from the second terminal to the reference terminal when the sign of the voltage is positive, that is, when the second terminal is positive. This condition is described by stating that the voltage has a positive polarity. If the sign of the voltage is negative, the voltage, keeping the same reference terminal, has a negative polarity. When voltages are alternating, the sign or polarity reverses many times each second. To obtain definiteness in writing circuit equations, a reference positive polarity for each voltage normally is assumed, and it is understood that the actual polarity is the same when the numerical value of the voltage is positive. If the numerical value is negative at any instant, the actual sign or polarity is understood to be the opposite of that designated originally.

The symbol used to denote a particular voltage should indicate the two points between which it is measured, as well as the assumed reference polarity. Two subscripts, appended to the letter symbol, one for the reference point and the other for the second point, have been used widely, and the order in which the subscripts occur may be used to indicate the sign or polarity initially (assumed the reference polarity). The essential question then is which of the two subscripts denotes the reference point. For example, if V_{ab} is the voltage in question, is the reference point the terminal denoted by *a* or the terminal denoted by *b*? If V_{ab} is positive, and *b* is the reference point, *a* is at a higher potential than *b*, or *a* is positive with respect to *b*. On the other hand, if *a* is the reference point, *b* is at a higher potential than *a*, or *a* is negative with respect to *b*. This difference in convention is then equivalent to a direct reversal of the voltage, so that failure to know which is intended is likely to be serious.

FOUR VOLTAGE SUBSCRIPT CONVENTIONS IN USE

Some authors make a distinction between a voltage which is a source voltage or an electromotive force and a voltage which is an impedance drop or load voltage, using the symbol E for the former and V for the latter. Many of the authors who follow this practice use one of the two possible subscript conventions for E and the other for V. There are two possible ways in which this may be done, but only one is in use, so far as the authors are aware, namely, the first subscript *a* designates the assumed reference point for E_{ab}. Under this assumption, the potential rises from the first terminal, *a* to the

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Full text of miscellaneous paper **48-1,** "A Critical Analysis of Voltage Convention, and Double-Subscript Notations," scheduled for presentation at the AIEE winter meeting, Pittsburgh, Pa., January 26–30, 1948.

Myril B. Reed is a professor of electrical engineering and **W. A. Lewis** is dean of the graduate school, Illinois Institute of Technology, Chicago, Ill.

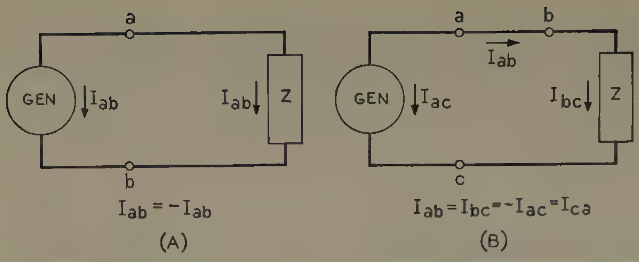


Figure 1. Double-subscript designation of currents

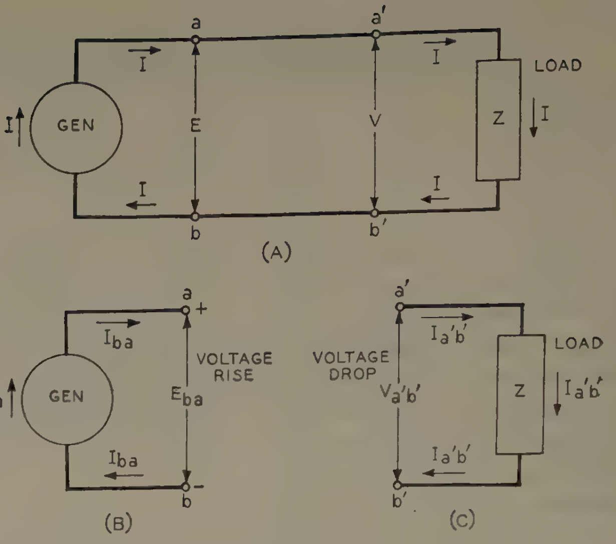


Figure 2. Voltage rise and voltage drop in a simple circuit

second, b, and the symbol E_{ab} denotes a voltage rise from the first subscript to the second, when E_{ab} is positive. The assumed reference point for the impedance voltage V_{ab} is then the second subscript b; a is at higher potential than b when V_{ab} is positive and V_{ab} denotes a potential drop from the first subscript to the second. Consequently, for the same points a and b, when E_{ab} is positive, V_{ab} must be negative and conversely. With this convention for the same pair of points,

$$E_{ab} = -E_{ba} = -V_{ab} = V_{ba}$$

or

$$E_{ab} + V_{ab} = 0 \qquad (1)$$

Many textbooks follow this convention.[2–6] Other authors use the same subscript convention for both E and V. Some habitually use E, others V, and others may use both, but the order and meaning of the subscripts would be the same for either E or V measured between the same two points. Those who use both generally use E to denote a source voltage or electromotive force and V to denote a load voltage or voltage drop, but the subscript convention is the same for both. Hence, with this convention, applied to the same two points,

$$E_{ab} = -E_{ba} = V_{ab} = -V_{ba}$$

or

$$E_{ab} - V_{ab} = 0 \qquad (2)$$

which may be contrasted with equation 1.

However, authors who agree on this second convention divide into three groups:

1. Those who represent all voltages in the sense of voltage drops from the first subscript to the second, so that the second subscript is the assumed reference point. With this convention, when E_{ab} or V_{ab} is positive, a is at a higher potential than b, and the potential falls from a to b.[7–11]

2. Those who represent all voltages in the sense of voltage rises, from the first subscript to the second, so that the first subscript is the assumed reference point. With this convention, when E_{ab} or V_{ab} is positive, b is at a higher potential than a, and the potential rises from a to b.[12–14]

3. Those who do not maintain a uniform practice, but who use the same symbol to represent a voltage rise or a voltage drop, as best suits the circumstances. With this convention the order of the subscripts is not significant without a statement that voltage rises or voltage drops are being represented, or something equivalent.[15,16]

Obviously the situation would be improved enormously if some one convention were adopted arbitrarily as standard, just as the selection of the counterclockwise direction of rotation for plane vector or phasor quantities has simplified the understanding of vector diagrams. The problem remaining is one of selecting which convention to adopt as standard and of obtaining agreement on it. In view of the diversity exhibited in the foregoing, it is evident that agreement will not be easy.

Although at least one other convention is possible—the reverse of the first one discussed—it is doubtful if it has sufficient merit to warrant preference over the four discussed. Hence, the discussion in this article will be confined to these four, and for convenience they are summarized and numbered as follows:

I. E_{ab} and V_{ab} have opposite reference polarities, and $E_{ab} = -V_{ab}$ E_{ab} is an assumed voltage rise from a to b. V_{ab} is an assumed voltage drop from a to b.

II. E_{ab} and V_{ab} have the same reference polarities, and $E_{ab} = V_{ab}$.

A. E_{ab} and V_{ab} are assumed voltage drops from a and b.

B. E_{ab} and V_{ab} are assumed voltage rises from a to b.

C. E_{ab} and V_{ab} may be either assumed voltage rises or assumed voltage drops from a to b, depending upon circumstances. The convention being used is supposed to be stated or indicated clearly by the context.

Each of these conventions has certain advantages and none is free from some disadvantages. Standardization therefore can be achieved only by some compromise of conflicting factors. This will be illustrated in the later discussion.

CURRENT CONVENTION

There has been general agreement for many years, in fact since Benjamin Franklin started it, that the direction of motion of positive charges in a circuit constitutes the direction of positive current. Unfortunately, perhaps, Franklin chose the least satisfactory of the two possibilities, but no real difficulty results from the fact that the preponderant electron motion is opposite to the direction of defined positive current, because it generally has been agreed upon. Even inside electron tubes, where the electron stream must be considered, the relation between the direction of electron motion and of current is definite, and no serious confusion arises.

When double subscripts are used for the designation of currents, the subscripts usually denote the terminals between which the current flows, and it universally is assumed that, when the quantity is numerically positive, positive current is directed from the first subscript to the second. In a simple circuit, current must be circuital, that is, it must traverse a complete circuit from the starting point through the load, through the source, and back to the beginning. If only two terminals are identified, as in Figure 1*A*, there are two paths between the two terminals, and double-subscript notation would be indefinite. Hence, to avoid ambiguity in current designation, every closed mesh must have at least three marked terminals or points, as in Figure 1*B* and it is understood that the current is denoted by the two terminals or points immediately adjacent to the branch in which the current is to be identified. With this limitation, the double-subscript method is definite and satisfactory for denoting the current in any individual branch and the assumed reference direction for a current thereby is established as positive from the first to the second subscript.

With this current convention, the Kirchhoff current equation can be written at any junction by equating the sum of the assumed inflowing currents to the sum of the assumed outflowing currents. When the unknown currents are determined by the solution of the network, by either the direct method of simultaneous solution of the equations or the indirect method of network simplification and expansion, as so often used in power-system problems, the signs of the numerical values will indicate the actual current directions. If the instantaneous value of a current is positive, it is flowing in the assumed positive direction. If its value is negative, it is flowing in the opposite direction.

Thus, no confusion arises in connection with the use of double subscripts to designate the circuit directions of currents. The basic difficulty, therefore, lies only with voltage designation conventions.

VOLTAGE DIRECTION VERSUS VOLTAGE POLARITY

In our opinion the source of the confusion regarding voltage designations stems from three sources:

1. From the failure to realize the number of possibilities available.
2. From the failure of writers to state explicitly the convention they use.
3. From the attempt, either explicitly or tacitly, to assign to a voltage the property of direction and to denote this direction by the subscripts.

The first two points of confusion already have been discussed. The last one will be considered in detail in the following.

Voltage actually appears physically as a potential difference between two points, and the only physical facts which have any significance are its instantaneous polarity and magnitude. This is true whether the sign and magnitude of the potential differences are fixed or are varying. By any measurements made exclusively at two terminals with a voltmeter, oscillograph, or other voltage measuring device, it is impossible to tell whether the voltage is an electromotive force (source voltage) or an impedance voltage drop. An oscillograph readily will determine the polarity of the voltage between terminal *a* and terminal *b* at any given instant as well as the voltage magnitude, but it will give no other information. Hence, the only correct significance of subscripts applied to voltage symbols, in addition to the designation of which two terminals are involved, is the designation of polarity (not direction).

As an example of what assigning circuit directions to voltages commonly leads to, consider Figure 2. In this figure is shown a simple circuit of a generator supplying a single load. For convenience the impedance of the generator and of the line are considered negligible. The current which traverses the entire circuit is denoted by ***I*** and its assumed reference direction is indicated by the current arrows. The electromotive force of the generator is denoted by ***E***, and the voltage at the terminals of the load by ***V***. In the usual power-system analyses, however, the entire circuit seldom is considered at one time, as usually the region of interest is either the generator or the load. For these analyses, the circuit may be divided into two parts as shown in Figures 2*B* and *C*. In Figure 2*B* the current ha sbeen provided with double subscripts, which, to conform with the direction shown in Figure 2*A*, should be written in the order *ba*. For this problem it has seemed logical to many authors to assign also a direction to the voltage which conforms to the direction of the current, because

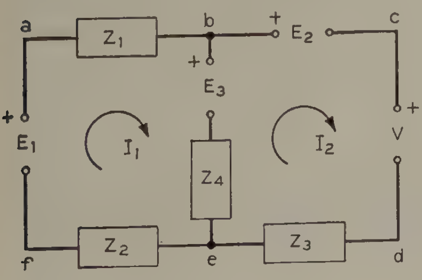


Figure 3. Single-subscript notation for voltage and current

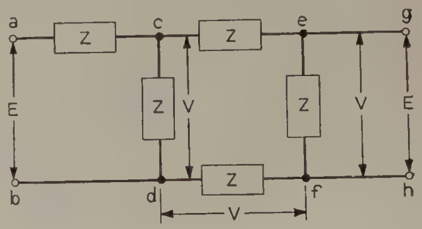


Figure 4. The application of double - subscript notation to a multi-mesh circuit

the voltage causes the current to flow in this direction. This is denoted by writing the subscripts in the same order as for the current, namely *ba*, giving E_{ba}. Automatically point *b* is assumed as the reference so that the voltage symbol then denotes an assumed voltage rise from *b* to *a*.

In Figure 2*C* the load circuit is considered. With current flowing in the same direction as in Figure 2*A*, the proper current subscripts are *a'b'*. It seems just as logical to direct the voltage in this instance in the same direction as the current it produces, and the order of subscripts naturally becomes *a'b'*, giving $V_{a'b'}$.

The voltage notations discussed in the two preceding paragraphs offer no particular difficulty when each part of the circuit is considered separately. However, if the two portions of the circuit are recombined, as in Figure 2*A*, confusion arises. In accordance with the initial assumptions, the impedance of the line is negligible, so that terminal *a'* may be made to coincide with terminal *a* and terminal *b'* with *b*. When this combination is made, there will be two voltage designations between the two terminals, one with the order *ba* and the other with the order *ab*, both determined by similar processes. If the voltage in question is to have a single, unambiguous designation, one of the preceding processes must be discarded arbitrarily, as obviously the one voltage which actually exists cannot be directed in both directions at once. It seems to us that the attempt to retain both directions at the same time has led to the use of two opposite conventions: E to denote voltage rise in the direction of a current in the source and V to denote voltage drop in the direction of a current in the load, leading to convention I.

From the preceding discussion, it should be evident that there is no special significance to the direction of a voltage, and attempts to assign direction to voltage quantities lead to a conflict which is at least confusing, if not misleading, to the initiated as well as the uninitiated. If the order of subscripts designates polarity only, no ambiguity need arise, because the voltage has only one polarity at a time.

SINGLE-SUBSCRIPT METHOD

The preceding discussion has been applied only to a notation using double subscripts, because it is only with a double-subscript notation that the letter symbols, with their appended subscripts, can give complete information regarding directions of currents and polarities of voltages. However, in most problems, a circuit diagram must be available at the same time to provide other information, and the diagram itself may be used to indicate the assumed reference current directions and the assumed reference voltage polarities. A widely used and entirely satisfactory method of establishing reference positive current directions is to place arrows indicating this direction in appropriate positions on the circuit diagram, as was done in Figure 2*A* or as shown in Figure 3. This method is particularly advantageous when mesh currents are used instead of branch currents, because each identified current then is considered to traverse completely an entire loop. The current in a particular branch then may be the algebraic sum of the two or more mesh currents which are assumed to traverse that branch. For example, the current in branch *be* in Figure 3 is

$$I_{be}=I_1-I_2$$

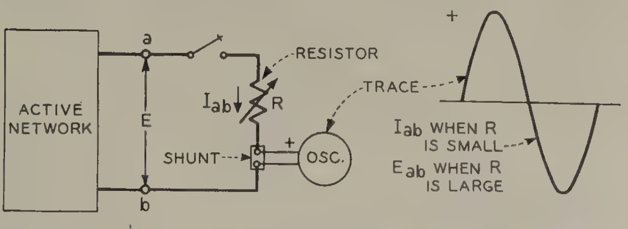


Figure 5. Current and voltage measurement at accessible terminals

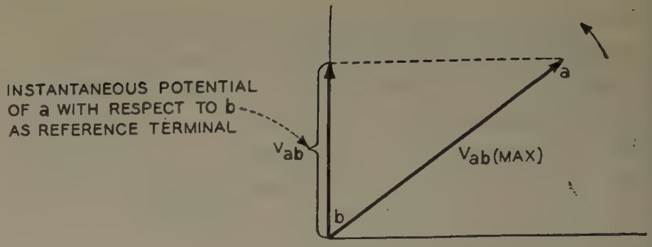

INSTANTANEOUS POTENTIAL OF a WITH RESPECT TO b AS REFERENCE TERMINAL
V_{ab}
$V_{ab(MAX)}$
a
b

Figure 6. Assignment of subscripts to vector terminals

With this notation the subscripts only need identify the particular current referred to, the information regarding direction being given by the arrows, and a single subscript is normally sufficient.

Many authors also use directed arrows or arrowheads on the circuit diagram to designate voltages, but here confusion is encountered. The direction of the arrow from one terminal to the other is used by some to designate the direction of voltage rise, from the tail of the arrow to the head, and by others to designate the direction of voltage drop, from the tail to the head. Still others use arrows directed both ways, in the direction of the voltage rise, with the symbol E, to designate source voltages or electromotive forces, and in the direction of voltage drop, with the symbol V, to designate load or impedance voltages. Hence, exactly the same difficulties arise that were described with double-subscript notation. The difference is that the difficulty now appears in the circuit diagram, rather than in the letter symbols used. Clearly a single physical voltage should not be identified by two arrows directed in opposite directions, at the same time, if confusion is to be avoided.

It should be pointed out that, when the arrow points in the direction of assumed voltage rise, the arrowhead is at the assumed positive terminal, and when the arrow points in the direction of assumed voltage drop, the arrowhead is at the assumed negative terminal. Therefore, the important fact regarding the voltage, which is its polarity, is not shown consistently, and the reader must know what method is being used before the voltage arrows convey any meaning to him. Because the arrowhead assumes the function of designating the voltage polarity when the convention is known, the subscripts no longer need to perform this task, and a single subscript, to indicate which voltage on the diagram is meant, is sufficient. Hence, single voltage subscripts may be used with this method, although there is no objection to the use of double subscripts to denote the two terminals involved provided the subscript convention and the arrow convention are consistent. The difficulty again seems to have arisen because of a confusion between voltage direction and voltage polarity, as discussed previously. What is needed is a clear-cut method of designating voltage reference polarity.

These difficulties may be avoided by designating only voltage polarity rather than direction of voltage rise or fall. In d-c circuits, the plus sign is used regularly to designate the assumed positive terminal. In most instances it is known that the actual polarity agrees with this assumption. In a-c circuits, a positive reference terminal also must be chosen to give definiteness to circuit relations, although the polarity reverses many times per second. There are many advantages to be gained in a-c circuits by using the plus sign to designate the reference terminal which is assumed positive with respect to the other. This practice has been used widely in designating terminals of switchboard instruments and relays and has been used on circuit diagrams in several texts.[2,5,17]

With this method the essential quantity, the voltage polarity, is designated clearly, with no possibility of confusion. This convention can be used with single-subscript designations of voltage but introduces no difficulties when combined with double-subscript notation for greater emphasis, provided a consistent double-subscript convention is employed. We strongly urge the use of the plus sign to indicate that terminal, of each pair between which voltage is measured, which is assumed positive for reference purposes.

It is absolutely essential that all voltages of a network have a reference polarity before Kirchhoff's law can be used, or numerical values of voltages can be interpreted in terms of actual voltage polarities in the network. If the single subscript method is used, it is best to assign reference polarities (denoted by plus signs) to all source voltages and to other voltages which are of particular interest in a problem. Impedance voltages (***ZI*** products) may not have reference polarities indicated explicitly, but if $\boldsymbol{V}=+\boldsymbol{ZI}$ is written, one reference polarity is implied for $\boldsymbol{V}$ and if $\boldsymbol{V}=-\boldsymbol{ZI}$ is written the opposite reference polarity is implied. In the first case the implied reference polarity is plus to minus in the reference direction of the current.

SELECTION OF A PREFERRED VOLTAGE CONVENTION

As already discussed, there are four conventions for double voltage subscripts now in use and an equally confusing situation exists when the single-subscript method is used. If this confusion is to be eliminated completely, it can be done only by the general adoption of consistent conventions which will be followed generally.

The fourth of the double-subscript conventions, identified as II*C*, is, in reality, simply the use of both conventions II*A* and II*B*, without definite preference. If any attempt is made to clarify the situation, some definite rules must be adopted, and the adoption of definite rules automatically eliminates convention II*C*.

Of the three remaining double-subscript conventions, the third, II*B*, is used least widely and is subject to the disadvantage that the equation for voltage drops must be written:

$$V_{ba}=-Z_{ab}I_{ab} \tag{3}$$

This necessitates an awkward minus sign in each such equation when the subscripts are written in normal order. Although this convention, if consistently applied, is entirely workable, it seems to us that preference surely would be given to one of the other two in any attempts at general standardization.

In our opinion, convention II*A* is best. The only virtue which convention I seems to offer is that the voltage equations (Figure 4) can be written in the form:

$$E_{ba}=V_{ac}+V_{cd}=I_{ac}Z_{ac}+I_{cd}Z_{cd} \tag{4}$$

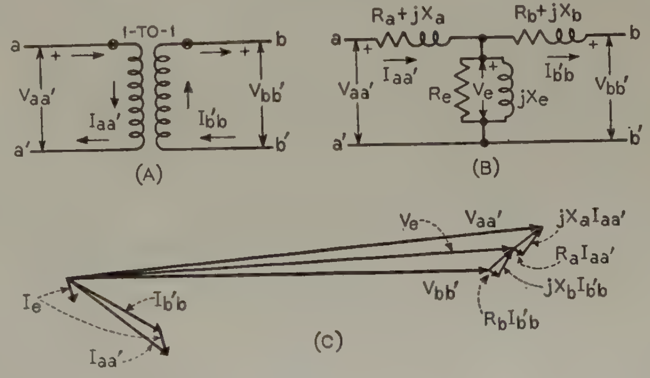
where the subscripts are written in the order of traversal of the mesh, the sum of the voltage rises being equated to the sum of the voltage drops. If convention II*A* is used, the equation for this same mesh is

$$\mathbf{E}_{ba}+V_{ac}+V_{cd}=E_{ba}+I_{ac}Z_{ac}+I_{cd}Z_{cd}=0 \tag{5}$$

which still is written in the order of traversal of the mesh. In this instance, the sum of all voltage drops is set equal to zero, an equally valid process. Now all second subscripts represent the assumed reference points,

Figure 7. Double-subscript notation applied to a 2-winding transformer

A—Transformer *B—Equivalent circuit* *C—Vector diagram*



whereas by convention I the subscripts on $\boldsymbol{E}$ and on $\boldsymbol{V}$ must be interpreted differently. The imaginary or, at best, doubtful advantage of equation 4 over equation 5, is accordingly more than offset by the disadvantage of having two interpretations for the double subscripts.

It is also desirable to assign the subscripts so that complete consistency is maintained in current and voltage measurement. Attempts to do this lead to a definite preference for convention II*A*, as shown in the following discussion. Assume that a voltage is available at two terminals, as shown in Figure 5, with the terminals marked *a* and *b* as shown. Suppose a resistor is connected between these two terminals and the current flowing through the resistor is measured by an oscillograph with the current denoted by $\boldsymbol{I}_{ab}$, in accordance with the accepted nomenclature for currents. If it is assumed now that the resistance is increased gradually, and if the sensitivity of the oscillograph is increased simultaneously, the wave trace on the oscillograph will remain more or less unchanged. As the resistance approaches infinity, the trace on the oscillograph becomes now a measurement of voltage instead of current. It is only logical to select the voltage subscripts so that they will have the same order as the current subscripts, and with this choice, the voltage between terminals *a* and *b* should be identified as $\boldsymbol{E}_{ab}$ or $\boldsymbol{V}_{ab}$. With [illegible] choice the voltage symbol represents a voltage drop from terminal *a* to terminal *b*, and the first subscript is then always at a higher potential when the voltage is numerically positive—essentially preserving the relation $\boldsymbol{V}_{ab}=\boldsymbol{Z}_{ab}\boldsymbol{I}_{ab}$. This coincides with convention II*A*. If the current were measured within the network on the source side of terminal *a*, instead of on the load side, it would be designated $\boldsymbol{I}_{ba}$ and a similar analysis would suggest the opposite choice of subscript order. However, in the most general case, measurement on the source side may not be possible as measurements of both current and voltage must be made at accessible terminals.

The only objection to convention II*A* of which we are aware, other than personal prejudice which always will enter, is that some difficulty is encountered when it is attempted to attach the subscripts to the ends of a voltage vector. With this convention, the terminal denoted by the second subscript is the reference point, as *b* in $\boldsymbol{V}_{ab}$, so that a vector must denote the potential of the point denoted by the first subscript as *a* in this instance, with respect to the reference point, *b*, as shown in Figure 6. The projection of the tip of a rotating plane vector on the reference axis is proportional to the instantaneous magnitude of the voltage, and, when positive, the potential of the first point, *a*, is greater than that of *b*. Hence, the tip of the vector must correspond to the first subscript, and the tail of the vector to the second subscript or reference point. Such a convention is perhaps contrary to the usual ideas of assigning vector terminations. Actually assigning a particular subscript to one end of a vector is a questionable practice, but if it is done with this convention, correct results can be obtained only by assigning the first subscript to the arrow end and the second subscript to the tail end.

To the authors, this objection seems the lesser of the difficulties, so that convention II*A* is definitely preferable.

SUMMARY AND RECOMMENDATIONS

The following résumé of the current and voltage conventions recommended by the authors, in conformity with convention II*A*, is submitted for the consideration of the Standards committee of the AIEE.

If Double Subscripts Are Used on Current Symbols

1. The double subscripts on a current symbol should designate, from the first to the second subscript, the reference positive direction of that current, independently of whether the current is increasing or decreasing.

2. Positive numerical value of a current indicates that the current in the circuit is in the reference positive direction, from the first to the second subscript points.

If Single Subscripts Are Used on Current Symbols

3. Arrows should be used to designate the reference positive direction of current on the circuit diagram.

4. Positive numerical value of a current indicates that the current is in the reference direction.

If Double Subscripts Are Used on Voltage Symbols

5. The double subscripts on any voltage symbol should designate the reference polarity of that voltage with plus at the first or left-hand subscript, regardless of whether the voltage is considered as generated or consumed.

6. Positive numerical value of a voltage indicates that the actual and reference polarity are the same.

If Single Subscripts Are Used on Voltage Symbols

7. Any voltages designated on the network diagram should have reference polarities indicated by a plus sign near the positive reference terminal, independent of reference current direction.

8. As for double subscripts, positive numerical value of a voltage indicates that the reference and actual polarities are the same.

Appendix I. Convention II*A* Applied to a 2-Winding Transformer

For convenience, the transformer of Figure 7 will be assumed to have a one-to-one ratio and an air core, although the final results will be applicable to iron-core transformers equally well. Standard transformers for power purposes, in accordance with American Standards for Transformers *C 57* will have one terminal of each winding identified, and if the two windings are wound concentrically in the same direction, the identified terminals will occur at the same ends of the winding, as indicated in the figure by the small crosses in the circles at the top.

In choosing the reference terminals for designating voltages, the marked terminals may be chosen as the reference terminals or as the nonreference terminals, as desired. However, it is somewhat more convenient to choose the marked terminals consistently as the nonreference terminals, so that the voltage symbols of both primary and secondary will denote the potentials of the marked terminals measured with respect to the corresponding unmarked terminals as reference. Then the voltage symbols become $V_{aa'}$ and $V_{bb'}$, in accordance with convention II*A*, and the plus mark, if used, will be placed at the top, as shown.

The positive directions of the current now may be chosen, quite independently of the assumed polarities of the voltages, as desired. For 2-winding transformers, the most convenient choice from the system viewpoint is usually to select positive currents as entering the marked terminal of the primary, in this instance, $I_{aa'}$, and leaving the marked terminal of the secondary, in this instance $I_{b'b}$ as shown in the figure.

As the two windings are assumed to be wound in the same direction, the magnetizing effects of positive currents will oppose, as may be seen in Figure 7. Let L_{aa} and L_{bb} be the self-inductances of the two windings, and L_{ab} the mutual inductance between them. Also assume that positive flux linkages in each winding are given by positive currents in that winding and by any fluxes produced by other positive currents which link the winding in the same direction. Then if the flux linkages are denoted by λ, the flux linkages of the two windings become

$$\begin{aligned}\lambda_{aa'} &= L_{aa} i_{aa'} - L_{ab} i_{b'b}\\ \lambda_{b'b} &= L_{bb} i_{b'b} - L_{ab} i_{aa'}\end{aligned} \qquad (6)$$

In these equations, $i_{aa'}$ and $i_{b'b}$ denote the instantaneous values of $I_{aa'}$ and $I_{b'b}$ respectively. The minus signs arise because the magnetic effects of assumed positive currents oppose.

In accordance with convention II*A*, all voltages represent voltage drops, from the first subscript to the second. In the primary winding, this drop will occur in the direction of positive currents, so that the equation of voltage drops should be written with a positive sign, as

$$\begin{aligned}v_{aa'} &= R_a i_{aa'} + \frac{d\lambda_{aa'}}{dt}\\ &= R_a i_{aa'} + L_{aa}\frac{di_{aa'}}{dt} - L_{ab}\frac{di_{b'b}}{dt}\end{aligned} \qquad (7)$$

in which $v_{aa'}$ denotes the instantaneous value of $V_{aa'}$ and R_a is the resistance of the primary.

In the secondary winding, when the voltage drop from *b* to *b'* is considered, the winding is traversed in the direction opposite to the assumed positive current direction, so that the voltage-drop equation should be written with a minus sign. This gives

$$v_{bb'} = -R_b i_{b'b} - \frac{d\lambda_{b'b}}{dt} = -R_b i_{b'b} - L_{bb}\frac{di_{b'b}}{dt} + L_{ab}\frac{di_{aa'}}{dt} \qquad (8)$$

in which $v_{bb'}$ is the instantaneous value of $V_{bb'}$ and R_b is the resistance of the secondary.

If these equations are changed to the corresponding vector forms in the usual way, the results are

$$\begin{aligned}V_{aa'} &= (R_a + j\omega L_{aa})I_{aa'} - j\omega L_{ab} I_{b'b}\\ V_{bb'} &= -(R_b + j\omega L_{bb})I_{b'b} + j\omega L_{ab} I_{aa'}\end{aligned} \qquad (9)$$

These equations may be placed in more usual form by defining leakage reactances as follows. Let

$$\begin{aligned}X_a &= \omega(L_{aa} - L_{ab})\\ X_b &= \omega(L_{bb} - L_{ab})\end{aligned} \qquad (10)$$

be the leakage reactance of the primary with respect to the secondary and the leakage reactance of the secondary with respect to the primary, respectively. Also let the exciting reactance be defined by

$$X_e = \omega L_{ab} \qquad (11)$$

When these quantities are substituted, equation 9 becomes

$$\begin{aligned}V_{aa'} &= (R_a + jX_a)I_{aa'} + jX_e(I_{aa'} - I_{b'b})\\ V_{bb'} &= -(R_b + jX_b)I_{b'b} + jX_e(I_{aa'} - I_{b'b})\end{aligned} \qquad (12)$$

These equations may be recognized as also applicable to the usual equivalent circuit for a one-to-one ratio transformer. The exciting current, I_e, and the excitation voltage, V_e, may be defined by

$$\begin{aligned}I_e &= I_{aa'} - I_{b'b}\\ V_e &= jX_e(I_{aa'} - I_{b'b}) = jX_e I_e\end{aligned} \qquad (13)$$

and substitution in equation 12 gives

$$\begin{aligned}V_{aa'} &= (R_a + jX_a)I_{aa'} + V_e\\ V_{bb'} &= -(R_b + jX_b)I_{b'b} + V_e\end{aligned} \qquad (14)$$

These equations are also applicable to an iron-core transformer. The essential modification required is represented in the equivalent circuit by adding a resistance branch, R_e, in parallel with the exciting reactance to include the effects of core loss, and to recognize that X_e is not a constant quantity during each cycle. As a result, I_e is no longer sinusoidal, as assumed in writing the vector equations, but it is so small that $I_{aa'}$ and $I_{b'b}$ still may be considered substantially sinusoidal and I_e may be represented by its equivalent sine wave, a current which has the same effective value and a phase angle θ with respect to V_e such that the product $V_e I_e \cos\theta_e$ gives the average core loss. The equivalent circuit is then that shown in Figure 7*B*.

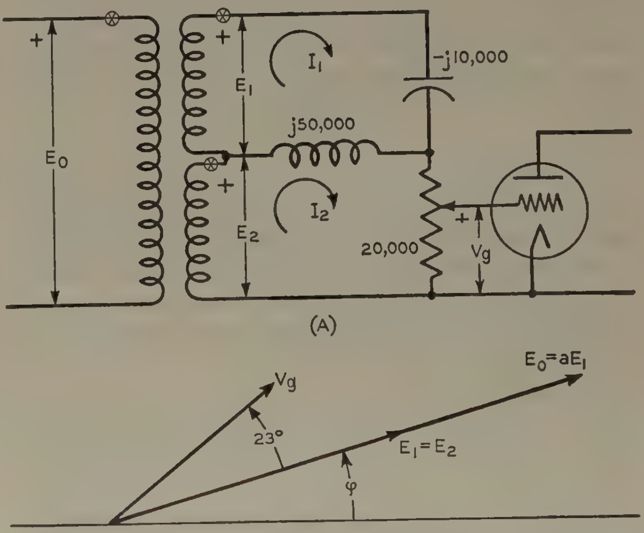


Figure 8. Single-subscript notation applied to an electron tube control

A—Circuit *B—Vector diagram*

The vector diagram corresponding to equation 14 is shown in Figure 7*C*. It should be noted that all voltages, $V_{aa'}$, V_e and $V_{bb'}$ are approximately in phase, and are drawn on the same side of the vector diagram. Although $\mathbf{V}_e$ may be thought of as the counter electromotive force of induction, and as such is directed opposite to $V_{aa'}$, it still has the same polarity as $V_{aa'}$, and so is approximately in phase when consistent reference points are maintained. Also the primary and secondary voltages, $V_{aa'}$ and $V_{bb'}$, have the same polarity at the same instant and are approximately in time phase. In short, the voltages are in approximately the same phase relation as if the transformer were omitted and impedances corresponding to the equivalent circuit substituted, the reference terminal now being a common point as shown in Figure 7*B*. Although these relations are a consequence of the arbitrary choice of reference terminals, they follow logically from a consistent choice on both primary and secondary.

Also the primary and secondary currents are approximately in phase in time, although considered to oppose magnetically in the windings. If one of the arbitrary positive current directions is reversed, the vectors will be approximately in opposition, but positive currents then must be considered to be aiding magnetically in the winding. With the choice given in the figures, positive current essentially is flowing through the transformer, in at the marked primary terminal and out at the marked secondary terminal at the same instant, just as in the equivalent circuit.

To us it seems much easier to keep these relations in mind than those arising from other conventional assumptions which result in primary and secondary voltages and currents being shown approximately in phase opposition. Still greater difficulty is encountered when the voltage of magnetic induction is considered as a voltage drop in the primary and as a voltage rise in the secondary, as often is done when convention I is followed.

It should be noted also that the sign associated with the law of magnetically induced voltages in reality is determined by the arbitrary choice of voltage polarity and current direction. For example, when positive current traverses the circuit in the direction from the first voltage subscript to the second, as in equation 7, the voltage of magnetic induction is

$$e_L = \frac{d\lambda}{dt} = N\frac{d\Phi}{dt} \tag{15}$$

but when the assumed positive current direction in the circuit is from the second subscript to the first,

$$e_L = -\frac{d\lambda}{dt} = -N\frac{d\Phi}{dt} \tag{16}$$

as in equation 8. As the first condition normally will occur when loads are considered, and the second when sources are considered, this concept appears preferable to the normal assumption that a minus sign always should be applied. In other words, the determination of the appropriate sign is made in exactly the same way as for resistance drops in applying Kirchhoff's voltage law to any loop.

Appendix II. Single Subscript Method

As an illustration of the use of the single-subscript method, the relative polarities of $\boldsymbol{E}_0$ and $\boldsymbol{V}_g$ of Figure 8*A* will be computed. The internal impedance of the transformer will be neglected and the grid current will be assumed as zero.

The two mesh equations for this network are then—equating assumed voltage rises to the assumed voltage drops—

$$\boldsymbol{E}_1 = j40{,}000\,\boldsymbol{I}_1 - j50{,}000\,\boldsymbol{I}_2$$
$$\boldsymbol{E}_2 = \boldsymbol{E}_1 = -j50{,}000\,\boldsymbol{I}_1 + (20{,}000 + j50{,}000)\,\boldsymbol{I}_2$$

The solution of these equations is

$$\boldsymbol{I}_1 = 10^{-4}\,\frac{2+j10}{5+j8}\,\boldsymbol{E}_1$$

$$\boldsymbol{I}_2 = 10^{-4}\,\frac{j9}{5+j8}\,\boldsymbol{E}_1$$

and the voltage from grid to cathode is

$$\boldsymbol{V}_g = \boldsymbol{I}_2 k\,20{,}000$$

where $0 \leqq k \leqq 1$ is determined by the position of the grid tap. Therefore, as the assumed polarity of $\boldsymbol{V}_g$—marked on the diagram—coincides with the assumed polarity of $\boldsymbol{I}_2R$—plus to minus in the direction of assumed current,

$$\boldsymbol{V}_g = k\,1.91\,\underline{/23^\circ}\,\boldsymbol{E}_1$$

With a primary to secondary turn ratio of a,

$$\boldsymbol{V}_g = \frac{k\,1.91}{2a}\,\underline{/23^\circ}\,\boldsymbol{E}_0$$

The $t=0$, rms vector relation between $\boldsymbol{E}_0$ and $\boldsymbol{V}_g$ is shown by Figure 8*B*. The interpretation of this vector relation in terms of instantaneous polarities depends on two conventions:

1. The instantaneous polarity of a voltage coincides with the assumed polarity when the instantaneous value of the voltage is positive.

2. The *j*-component (or, if preferred, real component) of the maximum-value, rotating vector specifies the instantaneous condition.

Consequently, from the rotating vector forms,

$$\boldsymbol{E}_0(t) = \sqrt{2}\boldsymbol{E}_0\epsilon^{j\omega t} = \sqrt{2}E_0\epsilon^{j(\omega t+\phi)}$$

$$\boldsymbol{V}_g(t) = \sqrt{2}\boldsymbol{V}_g\epsilon^{j\omega t} = \sqrt{2}\,\frac{k\,1.91}{2a}\,E_0\epsilon^{j(\omega t+\phi+23^\circ)}$$

the instantaneous voltages are

$$e_0(r) = \sqrt{2}\,E_0 \sin(\omega t+\phi)$$

$$v_g(t) = \sqrt{2}\,\frac{k\,1.91}{2a}\,E_0 \sin(\omega t+\phi+23^\circ)$$

A consideration of these last two equations will give complete information regarding the relation of these voltages at every instant. A simple approach, however, if relative polarities only are desired, is to imagine the vector diagram, expanded by $\sqrt{2}$ (or take it as is), rotating counterclockwise. So long as the vertical projections of the vectors are positive, the voltages will have the polarities assumed on the diagram. When both vertical components become negative, both polarities are opposite those assumed. There are also two intermediate conditions of one polarity as assumed and the other reversed. In any event, the actual polarities are determined completely at every instant.

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The Sign of Reactive Power—II

AN AIEE COMMITTEE REPORT

The closing discussion of the subcommittee on reactive power of the AIEE Standards committee upholds its original decision to recommend the change of the arbitrary sign of inductive reactive power from minus to plus. The majority of comments received on the original proposal have sustained the subcommittee's opinion.

As the subcommittee had hoped, the publication of the subcommittee report on the sign of reactive power[1] has brought forth a voluminous discussion.[2–36] A substantial plurality of those submitting discussions favors the proposal and the subcommittee therefore feels justified in reiterating its previous recommendation that the present sign of reactive power be reversed in the "American Standard Definitions of Electrical Terms."[37] Certain aspects of the discussion merit further consideration, and comments by the subcommittee are given in the following paragraphs.

Some of those discussers who favor the proposed change have added additional reasons for advocating the change, but they all were in agreement that the change should be made as proposed.

Those who were against the proposed change may be divided roughly into three groups:

1. Those who propose to retain the present standard for mathematical computations but to treat the flow of reactive power to an inductive circuit as positive in system operation. This proposal retains the present conflict between the most widespread practice of the utilities and the standard. Various suggestions have been made for defining new terms to reconcile or sidestep the conflict involved.
2. Those who propose to keep the present standard and either to ignore the present discrepancy between the practice of public utility systems and the standard or by some means not given to induce operating engineers to follow the standard.
3. Those who have drawn erroneous conclusions from the subcommittee report regarding the necessity of making changes in other standard definitions and then have proceeded to disapprove the proposed change in the sign of reactive power because of the erroneous conclusions drawn regarding other standard quantities.

Several discussers submitted comments regarding the desirability of uniform practice or making other contributions to the report without recording a definite preference for or against the proposed change in the sign of reactive power.

Some of those classified in the first two groups disapproving the proposed change in the present standard have maintained that no mathematical sign is essential when considering the flow of reactive power on the system, and that the use of a mathematical sign is necessary only for computation. It is, of course, quite true that readings of reactive power as recorded by system operators may be designated by an arrow or other nonmathematical symbol to indicate the direction of flow, or they need no designation at all if all values are flowing in the expected direction. If, however, the flow of reactive power at a point of measurement may reverse from time to time, or if several values of reactive power in different circuits must be totalized, no mathematical operations can be performed without assigning plus and minus signs to the values totalized. The position of the subcommittee is that the sign obtained by mathematical computation and the sign naturally used in the totalizing of reactive power readings should agree. With the present standard this is not possible unless the majority of utility companies using reactive power metering reverse their practice. The subcommittee does not believe that this will occur and the discussions submitted by utility operators lead to no other conclusion. Thus, unless the standard is changed, the well established practice of the utility companies will undoubtedly continue as the opposite of the existing standard.

Retention of the present standard when it is not followed is, in effect, no standard at all. Because the primary objective of a standard definition is to express for each term the meaning which is generally associated with it in electrical engineering work in the United States, the objective cannot be reached until either the definition is changed to agree with the most widespread practice or practice can be made to follow the existing definition. To operating engineers who see only disadvantage in the present standard, mere reiteration will not bring compliance.

F. B. Silsbee proposes[2] that the present standard be retained but that, in effect, the recording of reactive power be replaced by the recording of only the integrated flow of reactive power which he proposes to call

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This report was prepared by a subcommittee of the AIEE Standards committee, consisting of **R. C. Bergvall** (M '41, *chairman*), assistant to the vice-president, engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa.; **W. A. Lewis** (F '45, *acting chairman*), dean of the graduate school, Illinois Institute of Technology, Chicago, Ill.; **W. R. Brownlee** (M '38), investigations division, Commonwealth and Southern Corporation, Jackson, Mich.; **S. B. Crary** (M '38), central station engineering division, General Electric Company, Schenectady, N. Y.; **H. L. Curtis** (F '26), physicist, National Bureau of Standards, Washington, D. C ; **A. E. Knowlton** (F '30), associate editor, *Electrical World*, McGraw-Hill Publishing Company, New York, N. Y.; **W. C. Sealey** (M '38), engineer in charge, transformer division, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.; **H. K Sels** (F '45), transmission and substation engineer, Public Service Electric and Gas Company, Newark, N. J.; **H. M. Trueblood** (F '40), protection development engineer, transmission engineering department, Bell Telephone Laboratories, New York, N. Y.; **S. H. Wright** (M '34), electrical engineer, Ebasco Services, Inc., New York, N. Y.

"quadergy." Quadergy would be so defined that the time rate of flow of quadergy in a specified direction at any given point of measurement is the negative of the present standard reactive power. As real power is the time rate of flow of energy, it seems untenable to the subcommittee to adopt a new term, quadergy, for which the time rate of flow would become the negative of reactive power. If the recommendation of the subcommittee is adopted, the time rate of flow of quadergy would be equal to the reactive power, and consistency with energy and power relations will be maintained. As pointed out in Hollis K. Sels' discussion,[3] Silsbee's suggestion would not satisfactorily reconcile the difficulty in recording reactive power demand.

Edward W. Kimbark has pointed out[4] that the subcommittee report did not conform to the American Standard definition for susceptance.[38] This requires that the sign for susceptance be taken as positive for an inductive circuit, and therefore that admittance should always be written algebraically as $Y=G-jB$, not $Y=G+jB$. Kimbark is quite correct, as may be confirmed by a careful reading of the definition. The use of the standard sign for susceptance is not universally followed and the author of the report made this common error. As Kimbark has noted, the positive sign for inductive susceptance constitutes an additional reason for the adoption of the proposed change in the sign of reactive power, because in no other way can the sign of reactive power be made consistent with the standard definitions of inductive reactance and inductive susceptance. The subcommittee is glad to have Kimbark point out this fact. It is evident from Kimbark's discussion that if the sign of reactive power is not changed, consideration should be given to reversal of the sign of susceptance in the standard definition of susceptance.

Hollis K. Sels' discussion[3] points out that many companies use reactive power demand for metering purposes as well as the integrated use of reactive power. This constitutes an argument against Silsbee's proposal[2] because question would arise as to whether reactive power demand were being measured in accordance with the existing standard or as the time rate of flow of "quadergy," two quantities which would be the negative of each other under Silsbee's proposal.

Russell H. Lindsay's discussion[5] shows very well the difficulties which arise. However, he has taken power to be the product of the current and voltage vectors. This is not technically correct, although it may give correct results in special cases. His difficulties will be clarified by making proper use of conjugate vectors. To conform with the present standard, vector power must be defined as the product of the current and the conjugate of the voltage. Under the proposed change, vector power is the product of the voltage and the conjugate of the current. These results are the conjugate of each other. Lindsay has not made use of the conjugate notation but he has obtained the two results, in one case by using voltage as reference, and in the other case by using current as reference. By the consistent use of rigorous procedure his difficulties may be eliminated.

George A. Irland objects[6] to the name "reactive power." His criticisms are undoubtedly well taken but it is not practical to change the standard name of a well understood quantity until a new name has become accepted nor is such a change within the province of this subcommittee. Hence, the difficulties mentioned cannot be eliminated immediately. Perhaps Irland would like to propose a new name for consideration by the industry.

W. V. Lyon has pointed out[7] the essential purpose of the committee's report when he states "until a convention finally is established and is understood by all who are interested, there is confusion as to the meaning of the plus and minus signs." The subcommittee report points out the confusion which exists now regarding the signs attached to reactive power and submits that the confusion can be eliminated only by changing the standard to agree with the most widespread practice. The report of the subcommittee indicates that in spite of the existing standard, practice which is the opposite of the standard is growing and no amount of insistence upon the present standard will obtain uniformity. The only hope of establishing a convention which will be universally understood and followed seems to be in reversing the sign.

With regard to Lyon's questions, the term, "positive direction" is intended to mean an arbitrary direction in which a given quantity is flowing when its numerical value is positive. If the numerical value is negative, the opposite direction of flow is meant. Reversing the convention, of course, will not reverse the direction of rotation of a meter for specified conditions but will alter the interpretation placed upon it in terms of the conventions previously understood. Professor Lyon has indicated several examples showing possible ways of attaching plus and minus signs to quantities when it is necessary to differentiate between them in any given set of equations. To his list very well may be added a ninth quantity, in +, out −. This convention is used regularly in the sale of energy to customers. It certainly would be difficult for a customer to understand why this convention should be used for real power and energy and the opposite convention should be used for reactive power. Yet this is necessary if the present standard is applied consistently to present rate structures. The objection to the statement, "positive reactive power flow produces a voltage rise in the direction of the flow," is only that it is the opposite of the corresponding statement, "positive real power flow produces a voltage fall in the direction of the flow." All other things being equal, it certainly would be preferable if both kinds of flow produced the same effect. The objection to the construction of a reactive power meter which deflects to the right to indicate inductive reactive power with the present standard is that it conflicts with item 1 of Lyon's list of commonly accepted uses of plus and minus signs and does not solve the basic contradiction. If plus is to the right and inductive reactive power is minus when flowing in the direction which is plus for real power, the meter should be so designed that inductive reactive power would cause deflection to the left if inconsistency with accepted practices is to be avoided.

G. F. Sargent comments[8] that the advantages listed in the subcommittee report[1] on page 515 have been available to system operators and others for many years. This is perfectly true but he does not point out that obtaining these advantages, as is done today, is by violation of the existing standard sign for reactive power, not by compliance. If these advantages are to be retained and the standard for reactive power is to be a standard, there remains no alternative but to change the standard to agree with practice.

Reinhold Rüdenberg points out[9] that it is not sufficient to attribute merely a plus or minus sign to the reactive power, but that a further statement is necessary as to whether the power is delivered or received. The subcommittee report was intended to convey this impression. In the flow of real power, the signs plus and minus are used to designate the direction of flow of real power, plus when the flow is in the previously chosen positive direction, negative when the flow is opposite. The proposal by the subcommittee is to apply the same signs to the flow of inductive reactive power, positive when inductive reactive power flows in the same direction as that which would be positive for real power.

E. D. Doyle comments[10] on the use of the word absorb in the subcommittee report and indicates his preference for the word associate. The use of the word absorb was intended to convey not only the particular kind of reactive power but also its direction of flow. Inductive reactive power absorbed by a load is intended to indicate that the kind of reactive power required by an inductive circuit is flowing toward the load in question.

V. J. Cissna concludes[11] that the adoption of the proposed change would perpetuate two types of vars as system quantities. In this conclusion he is opposed diametrically to the conclusion of the subcommittee, as the subcommittee is proposing that inductive reactive power which is associated with system excitation and is supplied by an over-excited generator to an induction motor be designated arbitrarily as positive. The use of the minus sign then in all cases would indicate that the flow of this type of reactive power is opposite to the direction arbitrarily chosen as normal. With the proposed change, there no longer would be any need for asking the question as to whether the inductive type of reactive power or the capacitive type of reactive power is treated as positive. The standard would agree with the most widely accepted practice. He also points out that many textbooks will be made obsolete. Actually many books will require revision, but it is not the adoption of a standard but the practice which the standard recognizes that makes the textbooks obsolete. The purpose of the proposed change in standard is not to change practice but to obtain closer agreement between the standard and existing practice. Agreement between standard and practice should make easier the task of writing really satisfactory textbooks.

Cissna also states that two vector displacements will be legalized. This is not true as there is nothing about the use of a negative angle which changes the standard direction of rotation. The use of the conjugate of the present standard calls for the use of a negative angle in place of a positive angle in the construction of the diagrams as given by Cissna but makes no change in the standard direction of rotation.

Cissna also criticizes the development in the subcommittee report as being applicable only to a limited circuit element. The development was given in those terms for simplicity in explanation and is certainly not restricted to that case. The development of vector power as the product of voltage multiplied by the conjugate of current, or the reverse, is equally general and equally valid for any type of circuit.

Ludwig F. Roehmann concludes[12] that the adoption of the change would make necessary changing the sign of inductive reactance. This is clearly not necessary because the subcommittee report develops the mathematical basis for both concepts, treating inductive reactance as positive throughout. Roehmann's error is that he always has assumed voltage as reference in deriving his power expressions and thereby tacitly has assumed that vector power is, of necessity, the product of the conjugate of the voltage multiplied by the current. If he will take the conjugate of the current times the voltage, any discrepancy will disappear.

W. C. Sealey prefers[13] to eliminate any standard designations of signs for reactive power, leaving the choice open to the user. While this is one way of avoiding the inconsistency between the present standard and existing practice, it does not advance the cause of understanding through standardization. The majority of the subcommittee believes that the growth of practice opposite to the standard is now sufficient that reasonable agreement can be obtained.

J. G. Tarboux objects[14] to the change because of the difficulties it will place upon teachers explaining the mystery to their students. This difficulty will depend entirely upon when the concept of reactive power is introduced. If the concept of reactive power is defined and introduced during the discussion of series circuits, which regularly is undertaken before the discussion of parallel circuits, the concept will be established. Then the inversion involved in the study of parallel circuits is no more of a problem than the inversion of sign in the

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imaginary part of a complex number when admittance is taken as the reciprocal of impedance. The experience of other teachers has indicated that this is no problem when approached with a sympathetic viewpoint. It is much more difficult for the student to understand why what he has learned in college is the opposite of the common practice he encounters after leaving college.

H. B. Hansteen inquires[15] why the disadvantages of the present standard were not obvious at the time of the adoption of the original standard. At that time the concept of treating reactive power as a separate quantity to be transmitted and dispatched independently of real power recently had been introduced and was being used on a few systems. Those who were using this method were advocates at that time of assigning a positive sign to inductive reactive power but they were not then in the majority. In the time which has intervened this concept has become widespread and is in use on a majority of the larger systems in the country today. It is the continued growth of this concept which has rendered the standard adopted 13 years ago obsolete, if present widespread usage is taken as the criterion.

Hansteen also questions the lack of unanimity in the subcommittee report. One of the members of the subcommittee felt that the adoption of either standard was unwarranted and neither should be made a definite standard. Comments in support of this position have been presented as a part of the discussion by that committed member. Other members of the committee felt that no standard once adopted and approved by the International Electrotechnical Commission should be changed without the express concurrence of the IEC. The remaining members of the subcommittee felt that action would have to taken by one of the countries before action by IEC could be expected and, because the standard is not representative of current usage, that fact should be recognized by immediate change of the American standard.

F. de la Chard points out[16] that it is only necessary to declare voltage or current as the fundamental reference quantity and the other conventions will follow. Of course this is true because, if voltage always is taken as reference, the present sign for reactive power will follow naturally; and if current always is selected as reference, the opposite sign will be obtained just as naturally. The selection of the primary reference quantity, which may be voltage, current, or reactive power, is purely arbitrary. The others then may be derived in terms of the one defined first. The report of the subcommittee recommends in effect that current be used as the fundamental reference quantity and that the phase angle between voltage and current be measured from the current reference. The possible objection to de la Chard's suggestion is that there may be times when phase angle might be defined advantageously in either way without adversely affecting any other definition so long as only currents and voltages are involved.

G. M. Tatum indicates[17] that on his system magnetizing reactive power is considered as a positive quantity in system operation but is a negative quantity in system calculations. It is this possibility for confusion that the proposal of the subcommittee is trying to avoid.

A. B. Craig is suggesting[18] that two types of reactive power be defined in order to sidestep the difficulty. Many other discussers have implied that this would be unsatisfactory and that what is needed is concentration on one kind of reactive power just as there is only one kind of real power. The sign attached to the one kind of reactive power then would indicate only the direction of its flow with regard to an assumed reference direction.

R. C. R. Schulze's discussion[19] and H. P. St. Clair's discussion,[20] based on Schulze's, imply that the adoption of the proposed standard would reverse the sign of inductive reactance, as otherwise it would not be possible to calculate properly circuit voltage drops. This misunderstanding previously has been commented on and it has been indicated that the conclusion is erroneous. Later discussion with St. Clair has shown that the misunderstanding arises from the use of the vector power in voltage drop calculations. If the proposed change is made, vector power in voltage-drop calculations should be replaced by the conjugate of the vector power. Then no difficulties will be encountered, and the supposed objection is no longer valid.

C. F. Estwick points out[21] that the same difficulty in choice of sign is encountered if the reactive power is considered as the vector product of current and voltage. If the voltage operates on the current, one convention is obtained. If the current operates on the voltage, the opposite convention is obtained. The same necessity of choice exists and, if the sign of reactive power is settled clearly, the choice may be made as to how the vector product should be formed.

The comments by W. W. Parker, A. S. Brown, J. F. W. van der Meulen, R. B. Miller, L. B. LeVesconte, J. E. Hobson, Herman Halperin, C. F. Wagner, H. A, Dambly, R. D. Evans, R. Feinberg, and J. S. Gault[22–33] require no comments.

After reviewing all of the discussions, a large majority of the subcommittee believes that the original recommendation should be sustained and that the American Standards Association Committee on Electrical Definitions should reverse the sign of reactive power as defined in definition 05.21.050[37] so that definition and predominant practice may agree.

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3. **Hollis K. Sels.** Volume 66, January 1947, page 107.
4. **Edward W. Kimbark.** Volume 66, January 1947, pages 106–07.
5. **Russell H. Lindsay.** Volume 66, January 1947, pages 107–08.
6. **George A. Irland.** Volume 66, January 1947, page 108.
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8. **G. F. Sargent.** Volume 66, February 1947, pages 206–07.

9. **Reinhold Rüdenberg.** Volume 66, February 1947, page 207.
10. **E. D. Doyle.** Volume 66, February 1947, pages 207–08.
11. **V. J. Cissna.** Volume 66, March 1947, pages 321–2.
12. **Ludwig F. Roehmann.** Volume 66, March 1947, pages 322–3.
13. **W. C. Sealey.** Volume 66, March 1947, page 323.
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15. **H. B. Hansteen.** Volume 66, May 1947, page 515.
16. **F. de la Chard.** Volume 66, May 1947, page 515.
17. **G. M. Tatum.** Volume 66, May 1947, page 515.
18. **A. B. Craig.** Volume 66, May 1947, page 515.
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21. **E. F. Estwick.** Volume 66, May 1947, pages 516–17.
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25. **R. B. Miller.** Volume 66, May 1947, pages 514–15.
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27. **J. E. Hobson.** Volume 66, May 1947, page 515.
28. **Herman Halperin.** Volume 66, May 1947, page 515.
29. **C. F. Wagner.** Volume 66, May 1947, pages 515–16.
30. **H. A. Dambly.** Volume 66, May 1947, page 516.
31. **R. D. Evans.** Volume 66, May 1947, page 516.
32. **R. Feinberg.** Volume 66, May 1947, page 517.
33. **J. S. Gault.** Volume 66, May 1947, page 518.
34. **Edward B. Henry.** Volume 66, February 1947, page 207.
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Employer Practice Regarding Engineering Graduates—II

This report is supplemental to a previously published Engineers Joint Council report which presented and analyzed the results of a preliminary survey of employer practice regarding engineering graduates. The present report increases the scope of the survey by the inclusion of the results of various additional questionnaires.

THE PURPOSE of the Engineers Joint Council Subcommittee on Survey of Employer Practice Regarding Engineering Graduates was to learn directly from a representative group of industrial employers attitudes and policies in respect to the selection, training, placement, advancement, guidance, and professional activities of engineering graduate employees.

A trial questionnaire was sent in May 1946, to 174 employers of engineers, including small and large organizations, covering a sample of the principal industries making a practice of employing engineering graduates, most of whom have had more or less well defined courses of training and plans for advancement.

It was thought that this survey, which was a new one of its kind, would call attention to the methods of those following the better plans for the benefit of those who either had no plan, or had not perfected a plan to the best advantage of the engineering graduate and themselves, and this objective would be a very important step in the right direction. A report of this preliminary survey was published in April 1947.[1] That report included tabulated data received up to July 1, 1946, from 104 of the 174 employers.

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The value of the data, as expressed by the many people who read the report, convinced the committee that it should include in a supplementary report several questionnaires received after July 1, 1946. A few additional questionnaires were submitted to a group of consulting engineers, and returns of a representative portion of that group as of May 1946, are included in the present report.

The preliminary survey thus has been enlarged to include returns from 125 co-operators, with more than two million employees, among which is included a total of 38,000 engineering employees.

From these data Table I has been prepared in which individual industries are listed separately rather than by class groups, as was done in Table I of the preliminary report.

These industries have been arranged in order of the percentage of engineers to total employees, as shown in column 5, Table I. Group *A* contains industries in which the engineers constitute more than ten per cent of the total employees; group *B*, between two and ten per cent; group *C*, between one and two per cent, inclusive; and group *D* less than one per cent.

It will be noted (column 5, Table I) that combining all of the companies reporting, the average ratio of engineering graduates to total employees is 1.9 per cent.

So that the young engineer may see what opportunities lie ahead of him to become an executive in industry,

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Full text of a report issued by the Engineers Joint Council as supplementary to a previously published report (*EE, Apr '47, pp 286–9*) prepared by a subcommittee of the EJC Committee on the Economic Status of the Engineer from 104 returns received from a preliminary questionnaire survey conducted between May and August 1946. With this supplementary report, the preliminary survey has been enlarged to include returns from 125 co-operators. The Committee for Survey of Employer Practice Regarding Engineering Graduates is composed of the following society representatives:

E. G. Bailey (American Society of Mechanical Engineers), *chairman*
American Society of Civil Engineers, William N. Carey
American Institute of Mining and Metallurgical Engineers, Francis B. Foley
American Society of Mechanical Engineers, H. T. Woolson
American Institute of Electrical Engineers, R. C. Muir
American Institute of Chemical Engineers, Lawrence, W. Bass
National Society of Professional Engineers, William F. Ryan

Table I. Revised Summary of Significant Data From Survey of Employer Practice Regarding Engineering Graduates

Group	Code	Industry	Number of Co-operators (1)	Total Employment (2)	Total Employees in those Companies also Reporting Total Engineers (3)	Total Engineers (4)	Per Cent Engineers from Col. 3 and 4 (5)	Total in Executive Capacity—Department Heads to Chairmen of Board Engineering Executives Per Cent Engineering Executives to Total Executives: Total (6)	Engineers (7)	Per Cent (8)	Total Officers Engineering Officers Per Cent Engineering Officers to Total Officers: Total (9)	Engineers (10)	Per Cent (11)	Number of Engineers for Each Engineering Executive (12)	Number of Engineers for Each Engineering Officer (13)	Number of Engineers May 1946 and Estimated Number Needed by 1950: 1946 (14)	1950 (15)	Per Cent Anticipated Increase (16)	Anticipated Increase (17)
A	T	Colleges	8	4,785	1,310	585	44.6	114	67	59	70	33	47	8.6	17.7	660	840	180	27
	U	Consultants	6	2,426	2,406	880	36.7	51[3]	45	88	38[2]	29	76	19.6	30.4	780	650	−130	−17
		Totals and averages	14	7,211	3,716	1,465	39.4	165	112	68	108	62	57	13.1	23.6	1,440	1,490	50	3
B	I	Instruments	7	17,854	17,854	1,081	6.1	159	82	51	35	18	52	13.2	60.0	1,081	1,1 82	101	9
	F	Electrical	9	263,600	263,600	13,515	5.0	344[3]	111	32	136	70	51	122.0	193.0	13,440[2]	16,627	3,187	24
	D	Chemical	7	81,570	81,570	3,408	4.2	276[1]	77	28	83	23	28	44.4	148.0	3,533[1]	4,849	1,316	37
	A	Aircraft	7	52,500	52,500	2,049	3.9	389[1]	113	29	66[1]	16	24	18.1	128.0	3,944	4,530	586	15
	R	Utilities	10	53,878	48,628	1,857	3.8	456[2]	214	47	125[2]	57	46	8.7	32.5	1,857	2,128	271	15
	M	Petroleum	6	78,200	78,200	2,886	3.7	323[2]	111	34	77[1]	23	30	26.0	125.0	550[4]	750	200	36
		Totals and averages	46	547,602	542,352	24,796	4.6	1,947	708	36	522	207	40	35.0	120.0	24,405	30,066	5,661	23
C	C	Building	1	1,500	1,500	30	2.0	22	9	41	8	3	38	3.3	10.0	30	40	10	33
	J	Machinery	14	96,184	96,184	1,836	1.9	888[3]	393	44	152[2]	71	47	4.7	26.0	2,214[3]	2,961	747	34
	L	Paper	4	12,525	5,025	89	1.8	60[2]	17	28	21[1]	2	10	5.2	44.5	17[3]	20	3	18
	H	Glass	2	20,700	20,700	315	1.5	130	68	52	26	11	42	4.6	28.6	315	400	85	27
	V	Communication	1	413,000	413,000	4,700	1.1	450	135	30	175	45	26	34.8	104.0	4,700	6,000	1,300	28
	E	Coal and coke	2	6,200	6,200	62	1.0	62	25	40	25	10	40	2.5	6.2	62	105	43	70
		Totals and averages	24	550,109	542,609	7,032	1.3	1,612	647	40	407	142	35	10.9	49.5	7,338	9,526	2,188	30
D	Q	Textiles	1	1,070	1,070	10	0.9	[1]			4	3	75		3.3	10	13	3	30
	P	Soap	2	11,275	11,275	95	0.8	150	30	20	14	0	0	3.2		95	95	0	0
	N	Rubber	4	165,914	105,914	750	0.7	635[1]	80	13	53	12	23	9.4	62.0	750[1]	831	81	11
	B	Automotive	5	318,000	98,000	550	0.6	402[1]	97	24	38[1]	9	24	5.7	61.0	500[3]	660	160	32
	O	Shipbuilding	2	4,300	4,300	27	0.6	35[1]	6	17	7[1]	2	28	4.5	13.5	15[1]	20	5	33
	K	Metals	18	242,583	232,583	1,296	0.6	1,115[3]	336	30	158[3]	53	34	3.8	24.5	1,269[4]	1,420	151	12
	S	Transportation	6	394,921	394,921	1,765	0.4	2,376	362	15	415	122	29	4.9	14.5	939[3]	1,125	186	20
	G	Food	3	83,800	83,800	216	0.3	122[1]	24	20	50	1	2	9.0	216.0	216	260	44	20
		Totals and averages	41	1,221,863	931,863	4,709	0.5	4,835	935	19	739	202	27	5.0	23.3	3,794	4,424	630	172
		Grand Totals and Averages	125	2,326,785	2,020,540	38,002	1.9	8,559	2,402	28	1,776	613	35	15.8	62.0	36,977	45,506	8,529	23

[1], [2], [3], [4] Indicate number of co-operators not contributing specific data Revised to September 1947. Data as of May 1946.

columns 6, 7, and 8 (Table I) have been prepared to show the number of all executives, and of engineers who are executives in the respective industries, and the percentages of all executives who are engineers, while columns 9, 10, and 11 show corresponding figures for officers in these industries. Columns 12 and 13 show the number of engineers for each engineering executive and each engineering officer, respectively, in the various industries. These two columns reveal that in companies in group *D*, where the number of engineers is the smallest percentage of the total employees, namely 0.5 per cent (column 5), one out of every five engineers is an executive, and one out of every 23 is an officer of a company, while in group *B*, where the engineers, constitute 4.6 per cent of the total employees (column 5) one out of every 35 engineers is an executive, and one out of every 120 is an officer.

Another important revision of the preliminary report of this committee is shown in columns 14 to 17 (Table I), in which estimates of the number of engineers needed up to 1,950 are listed. The preliminary report showed the need over the 4-year period to be about 31 per cent of the engineer employees in 1946, while this report, covering more companies, with the results obtained by weighted averages instead of averages of percentages, shows the need of 23 per cent over the same interval, or about 6 per cent per year. This is a lower figure than one given in the Compton Committee Report,[2] which indicated an estimated need for engineers of 17 per cent per year.

A second survey by the committee of the American Society for Engineering Education (formerly the Society for the Promotion of Engineering Education) has been made, but the data are not yet available.

COMPARISON WITH OTHER DATA

In view of the recent publication of the report of the EJC Committee on the 1946 Survey of the Engineering Profession under the title "The Engineering Profession in Transition,"[3] it is interesting to compare some of the data contained in it with those which are included in the survey of this committee.

The first comparison will be found in Table II of this report. Here data from columns 1 and 4 of Table I of this report are compared with those presented on the distribution of engineers reporting major and minor industry fields of the previous report. The outstanding results of this comparison are that the returns from 125 questionnaires direct from industry revealed that there were 38,000 engineers in the principal industries selected, as a reasonable sample of those industries. The 1946 survey of the engineering profession, in which questionnaires were sent individuals, lists 28,000 engineers (see Table II, last column, of this report) in manufacturing industries. The survey of individuals includes in addition many engineers rendering personal services and engaged in construction work wherein special training courses are not usually given. Including all engineers in all classes of employment, the individual survey covers 36,855 persons.

In this connection it is interesting to note that according to the report, "The Engineering Profession in Transition," the number of self-classified engineers in the United States in 1946 was estimated at 317,500. This article states that 86,900 questionnaires were sent

Table II. Engineers in Industry

A Comparison of Those Reported in Two Surveys Made by Engineers Joint Council

	Employer Practice Regarding Engineering Graduates Sample Survey, May 1946		The Engineering Profession in Transition
	Number of Companies Co-operating	Number of Engineers	Number of Engineers
Education: colleges	8	585	1,793
Consultants, independent	6	880	954
Consultants, employees private firms			1,579
Instruments	7	1,081	
Other manufacturing industries			1,041
Electric equipment manufacturers	9	13,515	3,471
Chemical, soap, and so forth	9	3,503	2,408
Aircraft	7	2,049	1,125
Utilities, electrical and gas	10	1,857	3,527
Petroleum	6	2,886	1,230
Building products: cement, stone, glass	3	345	242
Machinery	14	1,836	1,820
Paper	4	89	248
Communications, telephone, telegraph, radio	1	4,700	1,554
Coal and coke	2	62	386
Other mining			1,867
Textiles	1	10	140
Rubber	4	750	351
Automotive	5	550	289
Shipbuilding	2	27	
Other transportation and equipment			602
Metals, iron and steel and nonferrous	18	1,296	2,334
Transportation: railroads	6	1,765	510
Food	3	216	388
Subtotal	125	38,002	27,859
Agriculture, forestry, and lumber			188
Printing and publishing			69
Construction: bridges, buildings, highways, sewerage, waterworks, and so forth			6,807
Water and sanitary services			612
Personal services, refrigerating, ventilating, insurance, wholesale and retail trade, legal and others not specified			3,853
	125	38,002	39,288
Deduct for duplication of consultants			2,533
Net total	125	38,002	36,855

Table IIIA. Engineers in Industry

A Comparison of Initial and Early Salaries as Reported in Three Surveys Made in 1946

	Ranges of Starting Salaries, Dollars per Month	Average Starting Salary, Dollars Per Month
EJC Committee for Survey of Employer Practice Regarding Engineering Graduate as of May 1946, largely bachelors	$150 –$250	$207
American Society for Engineering Education (Compton Committee) May 1946, bachelors only	125 – 320	210
EJC Committee on the 1946 Survey of the Engineering Profession—(September–October)	Lower 10 per cent .. Upper 10 per cent	Median
"The Engineering Profession in Transition" under one year's employment—not starting salaries (see booklet,[3] page 8, Table 1.22)	181 – 298	231
Engineers by professions, under one year, including all degrees (see booklet,[3] page 17)		
Chemical	(200)* .. (340)*	256
Civil	192 .. 311	243
Electrical	(170) .. (400)	237
Mechanical Industrial	178 .. 286	225
Mining-metallurgical	(150) .. (320)	236
Other	(150) .. (320)	224

* Items in parentheses are near extremes from pp. 76, 77, and 78 of "The Engineering Profession in Transition" (booklet)[3], not lower and upper ten per cent.

Table III*B*. Approximate Increases in Salary

Source of Information	Length of Experience	Salary (Dollars Per Month)
Employer practice reported by employers, May 1946 (mostly bachelors)	Start	$207
	6 months	224
	12 months	237
	18 months	257
	24 months	267
"Engineering Profession in Transition" (see booklet, page 8, Table 1.2a)	Under 1 year	231
	1 year	232
	2 years	262

Table IV. Distribution of the Engineering Profession by Occupational Status and General Field of Employment, 1946

From EJC Survey, "The Engineering Profession in Transition," Per Cent

Occupational Status	Total	Chemical	Civil	Electrical	Mechanical Industrial	Mining Metallurgical
Teaching, college, university, and other	4.7	5.1	4.5	4.3	4.9	4.4
Consulting, independent	3.7	1.9	6.9	1.4	2.8	5.3
Consulting, private employee	4.3	2.7	3.9	5.6	4.7	4.5
Total consulting	8.0	4.6	10.8	7.0	7.5	9.8
Administration, management, nontech	3.7	1.3	2.4	1.9	2.3	4.0
Administration, management, technical	31.3	32.2	31.5	28.3	30.6	40.2
Construction, supervision	4.8	0.7	13.3	3.6	1.9	0.7
Personnel—labor problems	0.2	0.2		0.1	0.2	0.1
Total administration and management	40.0	34.4	47.2	33.9	35.0	45.0
Design	15.4	10.7	20.1	18.0	18.7	0.3
Development	7.0	17.0	2.5	9.3	7.8	4.6
Analysis and testing	2.2	0.9	1.2	3.0	3.2	2.5
Drafting	1.1	0.2	2.0	0.8	1.7	0.1
Patents	0.3	0.4		0.3	0.3	0.6
Research, basic	0.6	0.7	0.5	0.4	0.7	1.4
Research, applied	6.0	13.8	2.2	4.9	5.4	14.6
Total design, research, and development	32.6	43.7	28.5	36.7	37.8	24.1
Estimating	1.1	0.3	2.0	1.1	0.8	0.5
Inspection	0.9	0.2	1.2	1.0	0.8	0.9
Installation	0.6	0.1	0.2	1.4	0.7	
Maintenance	2.0	0.5	2.0	2.8	2.5	0.2
Operation	2.5	3.1	0.9	3.5	1.9	6.0
Production	2.2	5.2	0.2	0.9	2.6	5.3
Safety engineering	0.3	0.1	0.2	0.2	0.2	0.6
Total manufacturing and production	9.6	9.5	6.7	10.9	9.5	13.5
Sales	4.4	2.3	1.5	6.5	4.8	2.4
Editing and writing	0.7	0.4	0.8	0.7	0.5	0.8
Total sales, and so forth	5.1	2.7	2.3	7.2	5.3	3.2
Total—per cent	100.0	100.0	100.0	100.0	100.0	100.0
Total engineers reported above	36,546*	3,624	8,601	9,239	8,708	2,780
Number reporting as student, unemployed, retired, or other occupations not specified (not included in per cent and total)	1,089	48	266	217	196	75

* Includes 2,429 other engineers, and 1,362 nonengineering, omitted from column analysis

out on August 28, 1946, to members of the engineering societies comprising those co-operating as EJC and members of the National Society of Professional Engineers, duplicate names having been eliminated. Usable returns numbering 47,272 were received up to November 18, 1946. The significance of these data is that the principal engineering societies have as members only 27.4 per cent of the engineers covered by the United States Census, although, presumably, many of the remaining 72.6 per cent should be eligible.

It is evident from the foregoing comparisons of the two reports that a large number of engineers can be covered for certain purposes by surveys directed to industry. It is a question, however, whether industry can be depended upon to give the detailed information that was asked for in the individual questionnaires. The questionnaire directed to industry asked for limited information that seemed to be of greatest benefit to the contributing members of industry, as well as to their employees and other engineering graduates.

SALARIES OF ENGINEERS

Tables III*A* and III*B* of this report compares the average starting salaries and approximate ranges of starting salaries offered to engineering graduates by industry, as covered by the survey of this committee in May 1946, and the survey of the American Society for Engineering Education, together with salaries reported in "The Engineering Profession in Transition" during the first year of employment. It is noted that the first two surveys show starting salaries of $207 and $210 per month respectively, while "The Engineering Profession in Transition" shows a median first year salary of $231 per month. It should be remembered that "The Engineering Profession in Transition" covers conditions as of September and October 1946, or about five months later than the report of the Committee on Employer Practice. It covers those employed under one year, which included increases over starting salary. On the other hand, it is recognized that many companies reporting their starting salaries as of May 1946 later have increased their salary scales.

In "The Engineering Profession in Transition" salaries of those employed under one year are given for the various branches of the profession. These data are listed in this report without comparison, as the employer practice survey made no distinction with respect to the branches to which the engineers belonged.

The employer practice survey included some data covering the advances in payments from a small percentage of the co-operators. These are listed in Table III*B*, and are compared with those of "The Engineering Profession in Transition" for experience under one year, for one year, and for two years, for all professions. This indicates a close agreement between the two surveys for experience at the end of one year and two years.

Table IV of this report is simply a recapitulation of data in "The Engineering Profession in Transition." It gives the percentage distribution of the engineering profession, by occupational status and general field of employment, in 1946, or by professional groups, as recognized in the Founder Societies.

The occupational status listings of the report have been regrouped to cover six main headings:

1. Teaching
2. Consulting
3. Administration and management
4. Design, research, and development
5. Manufacturing and production
6. Sales, and so forth

These listings covered on the average 97.7 per cent of all the occupational listings. The 2.3 per cent not covered includes engineers reported as student, unemployed, retired, or in other occupations not specified.

It is interesting to note that the administration and management occupational status covers 40 per cent of those reporting, and in different professional groups varies from 33.9 per cent in electrical to 47.2 per cent in civil engineering. Next in importance is design, research, and development, which averages 32.6 per cent, and varies from 24.1 per cent in mining to 43.7 per cent in chemical engineering. Then comes manufacturing and production, with 9.6 per cent average, and varying from 6.7 per cent in civil to 13.5 per cent in mining engineering. Consulting, both independent and private employees, averages 8 per cent, and varies from 4.6 per cent in chemical to 10.8 per cent in civil engineering. Teaching averages 4.7 per cent, and runs uniformly in all branches of the profession, varying only from 4.3 to 5.1 per cent. Sales, averaging 5.1 per cent, varies from 2.3 per cent in civil to 7.2 per cent in electrical engineering.

It seems to this committee that this information constitutes a most valuable portion in the report of the "1946 Survey of the Engineering Profession." It should be of great interest to educational institutions as well as to management, as it indicates where engineering graduates now are being employed.

REFERENCES

1. Employer Practice Regarding Engineering Graduates *ELECTRICAL ENGINEERING*, April 1947, pages 386-9.

2. The Outlook in the Demands for and Supply of Engineerng Graduates. *Journal of Engineering Education* (Lancaster, Pa.), volume 31, number 7, September 1946.

3. The Engineering Profession in Transition (booklet), A report prepared by **Andrew Fraser** for the EJC Committee on the 1946 Survey of the Engineering Profession. Engineers Joint Council New York, N. Y., 1947. This publication is available from AIEE headquarters, 33 West 39th Street, New York 18, N. Y., for $1 (50 per cent discount to AIEE members). Summary, **William N. Carey.** *ELECTRICAL ENGINEERING*, September 1947, pages 869–72.

The Spectroradiometer—a New Measuring Instrument

The Spectroradiometer is an instrument recently developed at the Lancaster plant of the RCA tube department of the Radio Corporation of America. It is used to measure such optical properties of luminescent materials as color, visual efficiency, peak energy, build-up and decay of fluorescence and phosphorescence under continuous and discontinuous excitation, flicker, stability, photoconductivity, and infrared quench and stimulation effects.

It uses a special cathode-ray tube which consists of a demountable vacuum chamber and a standard electron gun. Samples of luminescent materials to be tested are placed inside the chamber on a glass disk which may be rotated to pass each sample under the beam of electrons coming from the gun. Electrons strike and excite the luminescent material and the emitted light is reflected by a mirror into a spectroscope where a prism disperses the light into the various wave lengths of its spectrum. A motor turns the prism slowly causing small portions of this spectrum to fall in sequence on a photoelectric tube which produces an electric signal proportional to the amount of light at each wave length.

After being amplified the signal is applied to the vertical deflection circuit of a 12-inch cathode-ray tube oscillograph. The horizontal deflection provides the wave length scale which is produced by a potentiometer coupled to the motor shaft that turns the prism. The combination of vertical deflection indicating relative energy plus horizontal deflection giving wave length gives a "picture" of the spectral energy distribution of the luminescent material being measured.

The long-persistent screen of the cathode-ray tube permits as many as four separate curves to be compared simultaneously. A number of horizontal slow sweeps, provided by motor-driven potentiometers, permit build-up and decay measurements. In addition, a solenoid-operated shutter on a blue light source can be set to apply pulses of light to samples of luminescent material by manual or automatic control, cleverly duplicating the performance of double-layer radar screens.

Electrical Essay

This electrical essay is presented for the recreation of the reader. The author's question is: Is the reasoning true or false?

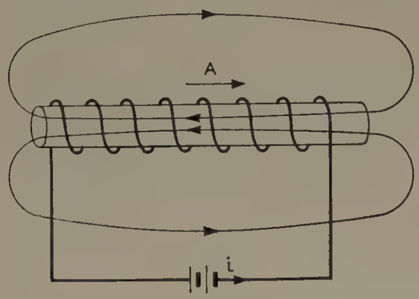

Figure 1

A long insulating cylinder is wound tightly from one end to the other with insulated wire, forming a solenoid as shown in Figure 1, and the ends of the wire are joined to a battery. A compass needle is set, as at *A*, just outside the solenoid at its middle. The compass needle will set itself parallel to the axis of the solenoid. True or false?

Answer to Previous Essay

The following is the author's solution to his previously published essay (*EE, Sept '47, p 872*).

QUESTION 1

In an *electrostatic* field, a line of force meeting the smooth surface of a conductor is always perpendicular to that surface. True or false?

The answer is: *false.*

Consider, as in Figure 2, two long cylinders parallel to each other and to a plane, from which the cylinders are equally distant. Let the potentials given to the cylinders and the plane be respectively +100, −100, and zero volts. Then, as Figure 2 shows, the zero equipotential surface passing between the cylinders and perpendicular to the plane will meet the plane in points *A*, such that the line of force approaching *A* makes an angle of 45 degrees with the plane.

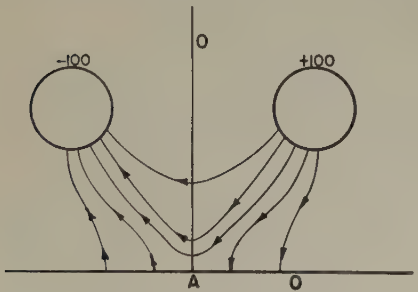

Figure 2

QUESTION 2

A rod of diamagnetic material mounted so, that it can turn freely, will set itself perpendicular to the direction of a uniform magnetic field in which it is placed. True or false?

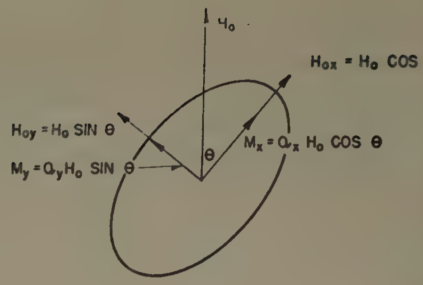

Figure 3

The answer is: *false.*

A body, with $B=\mu H$, when placed in an otherwise uniform magnetic field, H_o, will acquire a total magnetic moment M which generally will not be parallel to the field. It then will experience a torque $T=[M\times H_o]$. If μ is a material constant at each point of the body and independent of H, then it may be shown generally, that there are three mutually perpendicular directions for H_o relative to the body, such that M is parallel to H_o. These remarks are quite obvious for a body which is an ellipsoid, with constant μ. The three mutually perpendicular directions then will be the directions of the major axes.

If co-ordinate axes, x, y, z, are chosen along these three directions, then for a general H_o, with components H_{ox}, H_{oy}, H_{oz}, the body will have a total moment, M, with components:

$$M_x=a_xH_{ox}$$
$$M_y=a_yH_{oy}$$
$$M_z=a_zH_{oz}$$

where a_x, a_y, a_z are constants. a_x, a_y, a_z may be positive or negative, depending on whether the material is magnetic or diamagnetic. Let $a_x > a_y \geqq a_z$. This inequality is to be taken in an algebraic sense, that is, $-1 > -2$. Then it is seen readily that the body will tend to turn so as to make H_o parallel to the x-axis. For, in Figure 3, the moments M_x, M_y will have the values $M_x=a_xH_o \cos\theta$, and $M_y=a_yH_o \sin\theta$ respectively. The moment M_x reacting with field H_{oy} gives a torque $M_xH_{oy}=a_xH_o \cos\theta \sin\theta$, tending to reduce θ. The moment M_y reacting with H_{ox}, gives a torque $a_yH_o \sin\theta \cos\theta$ tending to increase θ. There will be a net torque, therefore, $T=(a_x-a_y)H_o \sin\theta \cos\theta$ tending to reduce θ. Hence, the body tends to set the x-axis, the one with the largest (algebraically) a coefficient parallel to the field.

It readily is seen that, for a rod-shaped body, with a constant μ, the direction for largest (algebraically) a is along the rod, whether the rod is magnetic or diamagnetic. Hence the rod, if free to turn, will line up parallel to the field if it is magnetic or diamagnetic.

Two of the author's coworkers, independently have verified experimentally that pieces of bismuth wire, hung by long threads, will set themselves parallel to the magnetic field.

J. SLEPIAN (F '27)

Associate director of research, research laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa.)

Progress in Power Generation—1940–46

AN AIEE COMMITTEE REPORT

A survey of the development and practice in the power generation field indicates that, in spite of wartime limitations, changes and improvements have taken place in recent years.

World War II marked the power generation field by requiring greater utilization of existing equipment which resulted in the testing and proving of designs developed during the later 1930's. The impetus of war needs led to extensive investigation and experimentation into fields which opened broad avenues to other ways of producing usable energy:

1. Atomic or nuclear energy.
2. Gas turbines.
3. Wind turbines.

These methods are still largely in the experimental stage though there are or were working units and components in each of these fields.

Despite the diminishing incremental gains to be expected from pushing steam pressures and temperature higher in steam plants, this method of performance improvement has been utilized by going to 2,300 pounds per square inch gauge pressure and several plants are being designed to use 1,050-degree-Fahrenheit temperature, some with reheating. Maximum ratings of steam station equipment have not been raised since the last report of this committee (1933–39), steam generator capacity remaining at about 1,000,000 pounds per hour and turbine capacity at about 145,000 kw.

To consolidate the performance gains of high-pressure high-temperature equipment, joint AIEE–ASME (American Society of Mechanical Engineers) turbine generator standards have been promulgated, in this way reducing somewhat the first cost of these units. It is estimated that about 25 per cent of the new units now on order follow these standards. Units larger than 20,000 kw are standardized at 850 pounds per square inch gauge and 900 degrees Fahrenheit initial conditions with the 40,000- and 60,000-kw units having alternate conditions of 1,250 pounds per square inch gauge and 950 degrees Fahrenheit.

Steam-driven auxiliaries virtually have disappeared in most new steam stations, electric drive lending itself to achieving higher over-all plant efficiency with the regenerative cycle. Hydroelectric stations have kept pace with the growth of capacity, most of the large installations being government-owned.

POWER PRODUCTION

Outstanding achievement on the home front during World War II was the production of electric energy by the central station utilities in response to all-time peaks in demand. From a total generation of 127,642 million kilowatt-hours in 1939, the output rose to a peak in 1944 of 229,766 million kilowatt-hours. Comparable capacities were 38,862,000* kw in 1939 and 49,799,000 kw in 1944. Thus there was an 80-per-cent increase in output with a 27-per-cent increase in capacity. Estimates have indicated that war needs took about 1 per cent of energy output in 1939 and 42 per cent in 1944.

Over-all capacity factors increased from 37.5 per cent in 1939 to 52.9 per cent in 1944, while the composite utilization factor increased from 72.8 per cent to 82.5 per cent for the same two years, indicating a considerable decrease in reserve capacity. This reflects the difficulty in obtaining new power producing equipment during the war as much of the turbine and boiler builders' fabricating capacity was devoted to providing equipment for the Navy and Merchant Marine.

This remarkable performance was achieved by:

1. Advancing clock time one hour during the whole year from 1942 to 1945.
2. Intensive use of system interconnections.
3. Industrial plants operating on a 3-shift 7-day week production schedule.
4. Addition of new high load-factor loads.
5. Operating with reduced capacity-reserve margins.

Other measures that helped in carrying the unprecedented loads were: bringing obsolete cold stand-by plants back into operation, using women to aid in plant operation, "brown-out" restrictions in certain parts of the country where energy shortages developed in hydro supply. In the coastal cities black-out practices helped in reducing demand though energy savings was not an objective in this program.

Plant operation was plagued by shortage of skilled operators, difficulty in obtaining maintenance supplies, and a marked drop in coal quality.

Despite the difficulties experienced during the war years, station fuel economy continued the long-time upward trend; national averages were 1.39 pounds of coal per kilowatt-hour in 1939 and 1.29 pounds of coal per kilowatt-hour in 1946.

Through this period the proportion of hydro capacity

Full text of paper **47-250**, "Progress in Power Generation—1940–46," presented at the AIEE Midwest general meeting, Chicago, Ill., November 3–7, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

This report of the AIEE power generation committee was prepared by its secretary, B. G. A. Skrotzki, associate editor, *Power*, New York, N. Y.

*Excludes New York City transit system plants.

and generation has remained practically constant when compared with the total power production activity as shown in Table I.

Of the 3,700,000-kw increase in hydro capacity from 1940 to 1946, about 3,300,000 kw was installed by governmental power districts. Practically all the large units were installed by government agencies, the few exceptions were 60,000 horsepower by the Nantahala Power and Light Company, 200,000 horsepower by Pacific Gas and Electric Company, and 21,400 horsepower by the Wisconsin Michigan Power Company.

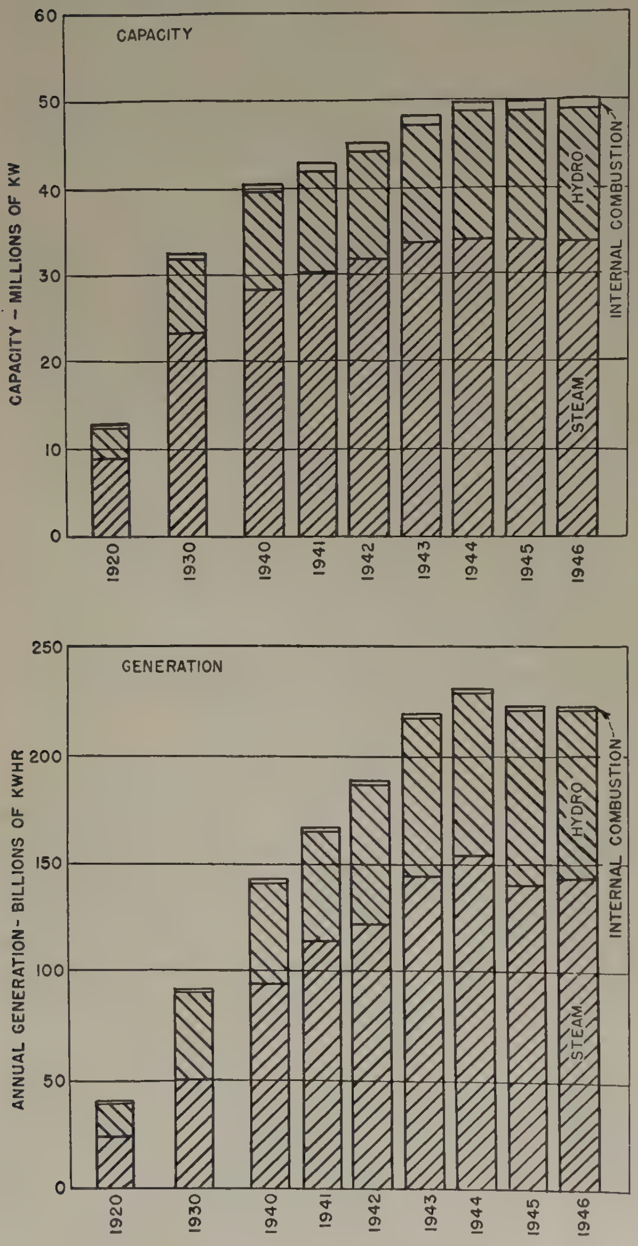

Figure 1. Comparison of central-station capacity and annual outputs in the United States

Rapid increase in annual generation was not accompanied by a comparable growth in station capacity during World War II

Table I. Proportion of Hydro Capacity and Generation

Year	Per Cent of Total Capacity	Per Cent of Total Generation
1939	28.3	33.8
1940	27.7	33.1
1941	27.5	30.4
1942	28.2	34.0
1943	28.6	33.6
1944	29.3	32.2
1945	29.9	36.0
1946	29.6	35.0

Governmental agencies and municipalities own and operate about 20 per cent of the total generating capacity in the United States. This includes all types of prime movers—steam, hydro, and internal combustion.

The most amazing aspect of the power demand picture has been the rapid nation-wide rise in load since the summer of 1946 (Figure 2). The abrupt drop in industrial load after *V-J* day was expected and resulted in declining weekly loads. This decreased demand was sustained in the early part of 1946 by the wave of strikes that passed through the country at that time. Resumption of civilian industrial activity and the increasing availability of home appliances and other factors have caused a record short-time load growth. Many systems have seen their reserve capacity virtually disappear. The resulting demand for new equipment has flooded the manufacturers' facilities to such an extent that steam turbine-generator deliveries are promised 36 months after placing the order and boilers about 18 months.

Various estimates indicate that the total capacity, central station and industrial, steam and hydro, to be installed within the next three years will be in excess of 12,000,000 kw.

STEAM PLANTS

Improvement of older low-pressure steam plants by installing superposed high-pressure high-temperature turbines and steam generators was followed in relatively few instances since 1940. This indicates that old-plant improvement opportunities largely had been exhausted in the period preceding 1940.

Application of higher pressures and temperatures have proved the practicability of operating at these increased steam levels. Surveys have shown that about 35 per cent of the units installed were for steam pressures between 300 and 699 pounds per square inch gauge, 45 per cent between 700 and 1,099 pounds per square inch gauge, and 20 per cent above 1,100 pounds per square inch gauge. In respect to throttle steam temperature about 30 per cent of the units were below 830 degrees Fahrenheit, 50 per cent from 830 to 900 degrees Fahrenheit, and 20 per cent above 900 degrees Fahrenheit. Highest temperature unit to go in service was at the Missouri Avenue station in Atlantic City, N. J.—a 25,000-kw turbine generator designed for 1,350 pounds per square inch gauge and 1,000 degrees Fahrenheit. There are several units scheduled to go into service in the near future with a 1,050-degree-Fahrenheit steam temperature. Some will use one stage of reheating at these high temperatures.

A strong trend in single-unit design is evident, with about 70 per cent of the turbines being supplied by a single steam generator, 27 per cent with two boilers, and about 3 per cent with three boilers. Many new station designs are incorporating the unit system where one boiler supplies a single turbine and all controls for boiler, combustion, turbine, auxiliaries, and switching are centralized at a common location for operating simplicity.

As to be expected, there was a wide distribution in the size of units installed—35 per cent were 20,000 kw and smaller, 45 per cent from 22,500 to 50,000 kw, and 20 per cent were 60,000 kw and larger. Largest unit installed was the 147,000-kw 1,250-pound per-square-inch-gauge 925-degree-Fahrenheit turbine-generator in the Fisk station of the Commonwealth Edison Company, Chicago, Ill. Although the large-unit group accounts for only 20 per cent of the number of units, they also represent about one-half the total kilowatts capacity. Boilers have shown the same wide diversity in capacity, about 65 per cent having a capacity of 400,000 pounds per hour and smaller. Largest boiler installed was 1,000,000-pound-per-hour 1,600-pound-per-square-inch-gauge 950-degree-Fahrenheit unit at the Sherman Creek station of the Consolidated Edison Company of New York, Inc.

Regenerative feedwater heating was employed in practically all the newly installed units. Number of turbine bleed points ranged from one to six—about 50 per cent had four bleed points, 25 per cent had three bleed points, and 10 per cent had two bleed points.

Pulverized-coal firing dominates the field of newly installed central-station boilers. About 50 per cent of the boilers are so fired and only about 10 per cent have some form of mechanical stoker, the remainder are natural-gas or oil-fired or some combination of two or all three methods. About one-third of the boilers with pulverized coal feed have slag-tap furnaces.

All of the steam generating units, with few exceptions, have either or both air heaters and economizers; about 60 per cent had both types of heat transfer surface, and 35 per cent had air heaters only.

Furnace heat release, a rough indication of the liberalness in the design of boilers, depends principally upon the types of fuel to be burned, in general, the higher the volumetric heat release, the tighter the design and the greater the dependence of quality fuels. For the new installations this figure varied from 14,500 to 34,500 Btu per cubic foot per hour, and about half of them were designed for 23,900 Btu per cubic foot per hour and less.

Two wartime developments, the floating power plant and the mobile power plant mounted on railway cars, have served their duty well during the national emergency and now are continuing to give service during the present period of unexpected load growth. Several systems in the South experienced such unprecedented load increases that these plants solved the problem of continuing service until conventional land installations can be constructed.

Many new stations are being located outside of city and town limits to avoid dust-nuisance complaints.

Outdoor and semioutdoor steam plants are finding increased acceptance, especially where the climate is relatively mild. In many designs the operating front

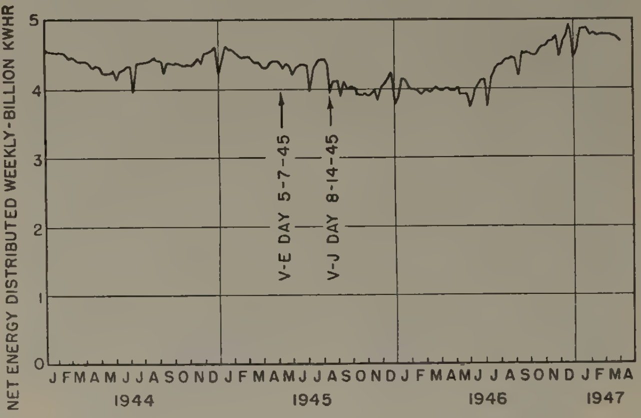

Figure 2. Energy distribution data

Recession in weekly energy distributed following V-J day was prolonged by numerous strikes. Rapid rise during summer of 1946 marked resumption of industrial activity. High levels maintained during early part of 1947 presages rapid future growth in demand. Data from the Edison Electric Institute

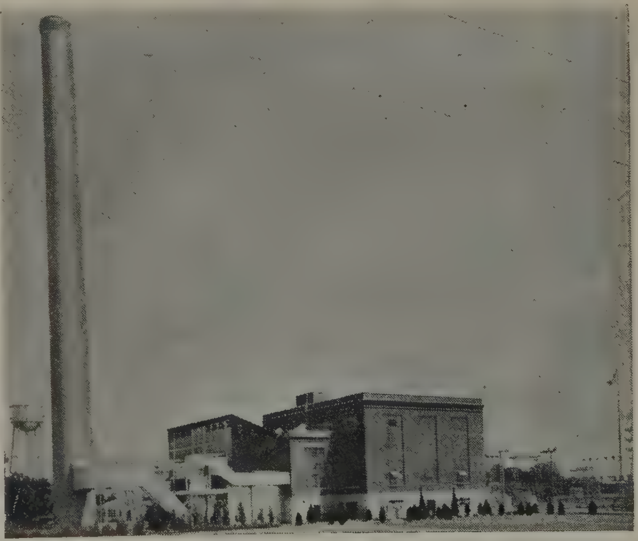

Figure 3. Ripley station of the Kansas Gas and Electric Company is of semi-outdoor design

The 28,750-kva turbine generator is housed completely as well as the firing aisle of the two 160,000-pound-per-hour boilers. The oil-fired boilers are outdoors covered by a canopy while the fans and air preheaters are completely out in the open at the boiler rear of the boiler forms one wall of the enclosed turbine room. Savings of 25 to 35 per cent in structural investment are reported, equivalent to about 5 per cent in plant over-all first cost. This saving is offset slightly by increased costs of making the outdoor equipment weatherproof.

Successful operation has been reported on the horizontal cyclone furnace installation at the Calument station of the Commonwealth Edison Company. Besides being able to burn low-grade coals, this furnace modifies the slagging problem associated with a conventional furnace and requires only crushing instead of pulverizing of the coal, consequent fly-ash reduction needs only a small cinder catcher installation, cleaning labor is minimized. The slagging characteristic is used to advantage in aiding the combustion process. In addition to these operating advantages, steam-generator space requirements are reduced appreciably. It has been estimated that over-all installation costs for a 75,000-kw plant would be reduced by about $6 to $6.50 per kilowatt with the cyclone furnace as compared with a conventional steam generator.

No new mercury plants have been installed since the Kearny, N. J., installation of the Public Service Electric and Gas Company and the outdoor plant at Schenectady, N. Y., of the General Electric Company. However, mercury plants of 5,000-kw capacity and up now are being offered for industrial use, using the condenser-boiler output for process heating, and up to 80,000-kw capacity for central stations, 30,000-kw mercury topping and 50,000-kw steam. A 7,500-kw mercury turbine has been ordered for the Pittsfield, Mass., plant of the General Electric Company to supply their 600-pound-per-square-inch steam system. The 10,000-kw mercury plant at Hartford, Conn., will be rebuilt for 15,000 kw.

Comparatively few central stations use steam drive for their auxiliaries and in most instances where they are provided serve the stand-by boiler feed pump. Motor drive for station auxiliaries dominates the field, but this complicates the control problem. Roughly a third of the boiler-feed-pump motors are provided with variable speed control. In the case of fans, motor speed control rarely is used; gas flow control is provided by dampers, vanes, magnetic and hydraulic couplings, 2-speed motor drives, or some combination of these.

A notable application is that of 3,600-rpm motors to drive large boiler feed pumps. Operating experience is awaited with interest.

The majority of auxiliary-drive motors are of the induction type while, with the variable speed couplings now available, several smaller installations have used the synchronous type. The installation of d-c motors has been discontinued. Practically all installations now use full-voltage starting for the auxiliary-drive motors.

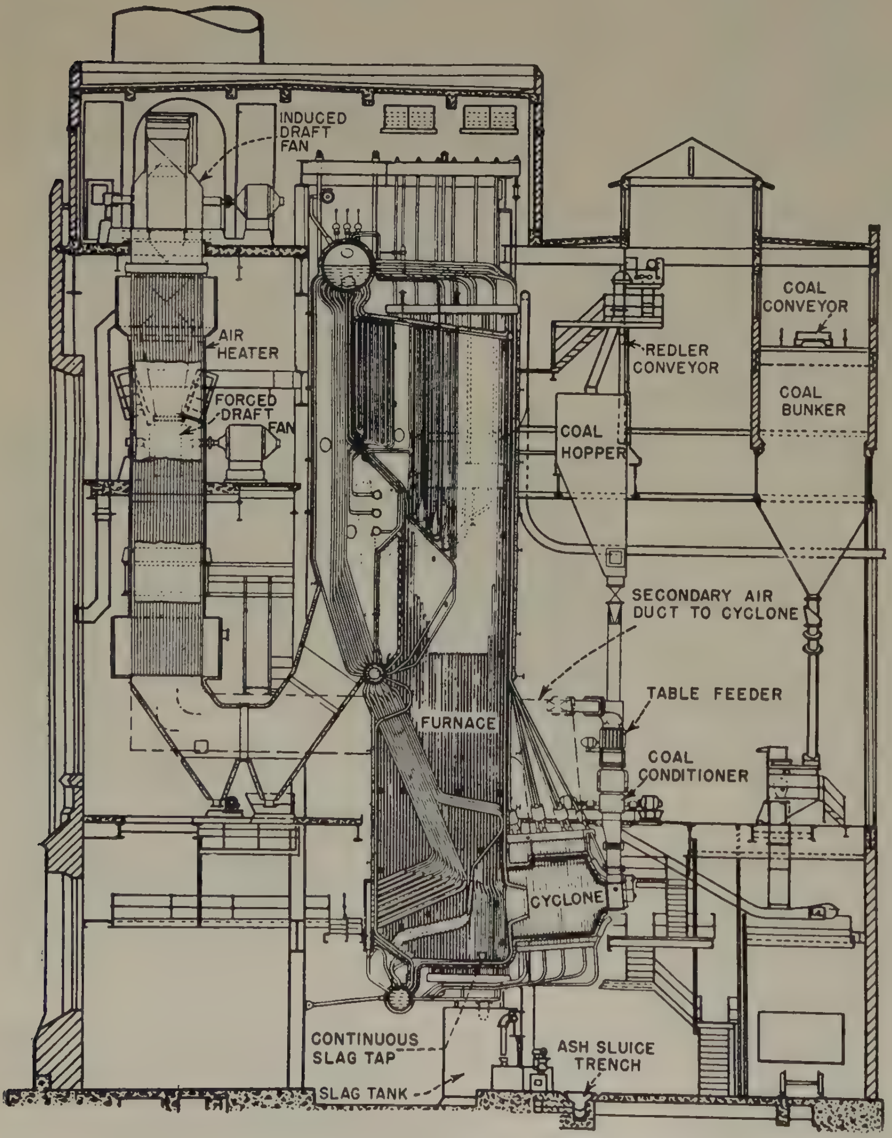

Figure 4. Boiler unit in Calumet station of Commonwealth Edison Company, Chicago, Ill., uses horizontal-cyclone burner to burn high-ash low-fusion-temperature coals

Advantages include reduced coal preparation cost, simplified ash handling, smaller size of boiler and dust-separating equipment, and lower over-all investment cost

Metal-clad switchgear and control have been proved in service and generally are accepted for station auxiliary layouts. Unit substations and power centers, usually with air-cooled transformers, form the modern arrangement for supplying low-voltage energy. These also include high-voltage gear where required. Air circuit breakers in all ratings through the 15,000-volt class virtually have replaced the oil type for power-plant auxiliary work.

Secondary network distribution systems for auxiliary supply have been installed in five stations and their performance has been reported favorably.

Unique co-operation between industrial-plant customers and utility generating stations was inaugurated in 1940–41 in the San Francisco Bay area by the Pacific Gas and Electric Company, San Francisco, Calif. Here three plants, essentially identical, Avon, Martinez, and Oleum, each supply a different oil refining company plant with steam and electric energy. These plants, 40,000 kw each, supply the oil refinery demand of 20,000 kw; excess energy becomes available for general distribution.

When supplying rated extraction steam at 225 pounds per square inch gauge from the automatic-extraction turbines they develop about 32,000 kw each. Under certain conditions of combined extracting and condensing operation they can produce more than 50,000 kw. The extracted steam supplies the oil refineries' evaporators furnishing steam from water supplied by the customer.

Generating plant furnaces can burn various fuels either individually or in combination; part of the fuel is composed of refinery wastes and taken as part payment for services supplied. Fuels that can be handled and burned are natural gas, oil, acid sludge, pitch, and pulverized petroleum coke.

HYDRAULIC STATIONS

Most of the new hydro capacity added has been installed by agencies of the Federal Government, especially in the larger plants (Table II). The rate of additions has maintained a phenomenal figure since 1936 as shown in Tables III and IV. Outstanding design has been the 60,000-horsepower 450-rpm Francis turbine installed by the Nantahala Power and Light Company near Franklin, N. C. This unit is built for a maximum net head of 1,000 feet, the highest for any reaction turbine of its size in the world. On test this turbine developed efficiencies of 93.7, 93, and 88 per cent at full, three-fourths and one-half load respectively.

Boulder Dam, Nev. and Ariz., on the Colorado River, under the supervision of the United States Bureau of Reclamation, is the largest plant in the world in terms of installed capacity. Designed for 1,835,000 horsepower, it now has 1,435,000 horsepower in operation. Four units of 115,000-horsepower each were added in the years 1941–44.

Shipshaw 2 on the Saguenay River in Quebec, Canada, holds the record construction time for a large hydroelectric plant. Although this development had been planned prior to 1931 when Shipshaw 1 (300,000-horsepower capacity) went into service, it was not built until the wartime demand for aluminum made construction imperative. The first unit started initial operation November 23, 1942, just 18 months after the start of

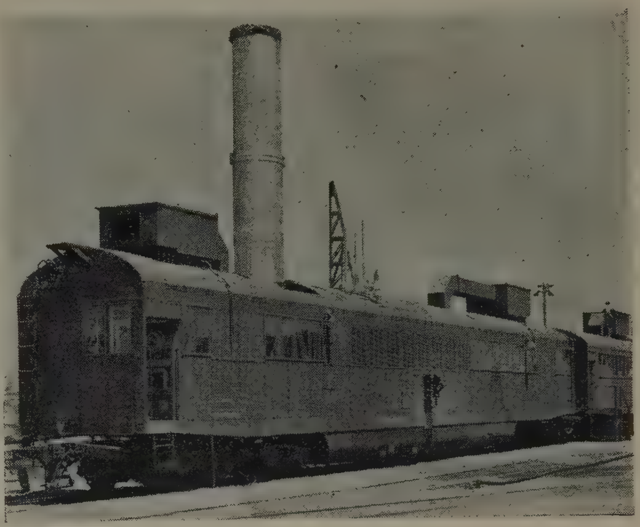

Figure 5. Boiler car of 10,000-kw mobile steam-electric generating station

Entire station consists of six railway cars housing complete equipment from oil-fired boilers to switchgear and transformers

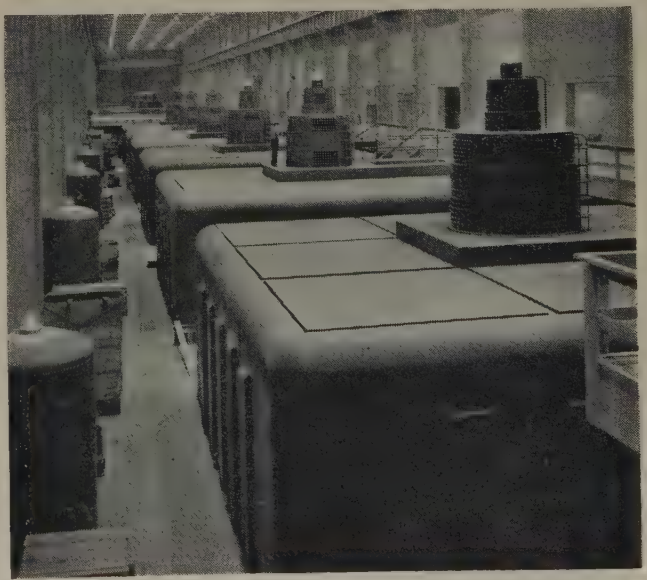

Figure 6. Generator room of Shipshaw 2 has the largest concentration of generating capacity, 1,140,000 horsepower in 12 units, housed in one building, in the world

First unit operated within 18 months of start of construction, 12th unit within 31 months construction; the 12th and last unit went into service on December 24, 1943. There are eight 100,000-horsepower and four 85,000-horsepower Francis wheels designed for a 208-foot head making a total of 1,140,000 horsepower. This is the largest hydroelectric development in the world contained in a single powerhouse.

Practicability of completely automatic and remote control of hydroelectric stations is demonstrated by the installation at Ocoee 3 on the Ocoee River, Reliance, Tenn., part of the Tennessee Valley Authority system. While automatic stations have been built and installed over the past 25 years, this installation with a 30,000-kva generator is the largest one to date utilizing this form of control. This station first went into service in April 1943 and its excellent service has led to plans to use it in three new stations under design. Ocoee 3 is controlled from Ocoee 2 located six miles away. Telemetering and control channels are provided by an underground telephone-type cable having 51 pairs of wires.

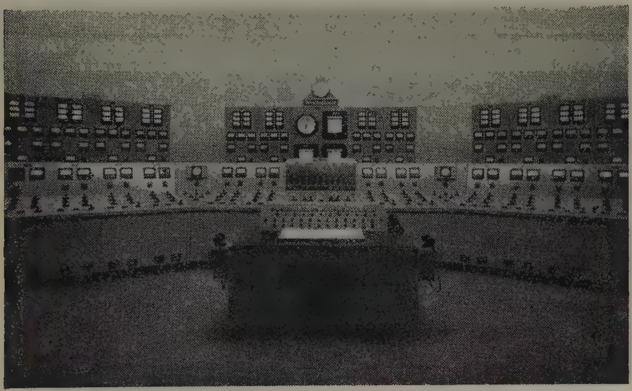

Figure 7. Control board for 12 hydro units in Shipshaw 2

Underground cable was selected because it was judged to provide practically trouble-free service with minimum of maintenance and the maximum number of completely independent channels. Other means of control communication were considered such as leased telephone circuit, carrier current, and overhead cable.

Considerable progress has been made in developing methods of testing hydraulic-turbine governors quickly and frequently. A notable instrument designed for this purpose has been described by J. E. Allen and W. B. Hess in a paper[131] presented at the 1947 AIEE winter meeting. This instrument directly draws a diagram of either kilowatts load or gate operating piston movement versus alternator frequency, in a manner analogous to a steam engine indicator card diagram. In addition to this diagram the instrument also records kilowatts load, gate operating-piston motion, and generator frequency on a strip chart. From both of these records the governor characteristics are analyzed quickly and aid in effecting repairs when needed. Progressive records help in showing in what respects a governor may be deteriorating and avoid costly shutdowns.

ELECTRIC APPARATUS

Studies have shown that the 3,600-rpm direct-connected exciter while performing on a satisfactory level had a poorer availability record than the rest of the turbine-generator unit. More attention to design of minor mechanical elements causing these outages are expected to improve their performance, one item being redesign of brush holders permitting brush replacement without shutting down the unit.

Electronic-type exciters first were applied to synchronous condensers in 1936 and to a synchronous generator in 1946. They promise to circumvent the problems of designing large 3,600-rpm direct-connected exciters. These new exciters offer possibilities of simple operation, low maintenance requirements, and high reliability. Normal maintenance can be carried on while the machine is loaded, even to the extent of replacing tubes. However, special attention must be devoted to the supply source; supply-voltage drops cause a drop in excitation voltage. This contingency can be counteracted by control devices.

Dry-type air-cooled transformers originally designed for central-station use have found application in the industrial and commercial fields. This transformer type differs from the original air-blast type in that the insulation contains a minimum of combustible matter, being principally made of air, porcelain, and glass. Though many have been subjected to severe service, no failures have been reported from such expected causes as moisture, dirt accumulations, and high temperature.

Air-blast circuit breakers for indoor heavy-power station switchgear are finding increasing favor. They are adaptable readily to standardized metal-clad switchgear installations. Standardization of this equipment during the last few years has shown positive benefits by allowing price reductions despite increasing costs.

Oil-type circuit breakers still are used largely for outdoor installations. Improvements in these circuit breakers include a 50-per-cent reduction in oil content resulting in higher speed arc interruptions and clearing time, and bettering the recycling duty. These circuit breakers now are built for voltages ranging from 115 to 230 kv with interrupting capacity of 1,000,000 to 3,500,000 kva. Standard circuit breakers are rated on a 5-cycle opening time basis. However, designs for 3 cycles at 138 kv and higher for 3,500,000 kva are also available. Oil circuit breakers of 5,000,000 kva rating are promised to be ready when needed.

From 1928 to 1938 turbine generators designed for 2-pole 3,600-rpm 60-cycle conditions were built for ratings as large as 81,250 kva at 0.8 power factor. In the period under discussion this rating has been raised to 100,000 kw at 0.9 power factor. Double-frequency vibrations which had been experienced on some of these high-speed units have been eliminated by machining relatively narrow cross-wise slots in the pole body at intervals along the body length. This equalizes the rotor-body rigidity on the two major axes and can be realized without removing an appreciable amount of rotor pole material.

Double-frequency vibratory forces inherent in the 2-pole generator stator cannot be eliminated. However, the magnitude of these forces transmitted to the stator frame and generator foundation are minimized effectively by isolating the stator core on flexible supports; these supports absorbing practically all of the vibration energy.

About 60 per cent of the central station generators installed during the period were hydrogen-cooled. Availability of hydrogen-cooled generators has been practically perfect. Most hydrogen-cooled generators were designed for 15 pounds per square inch gauge operation to obtain increased maximum rating, but only a few are operated at this pressure.

Water wheel generators, as in the past, are characterized by large dimensions. For this reason large-capacity units must be built in sections and assembled at the point of installation. This has led to problems of fabrication which largely have been solved in this period. Although building the components at the user's plant will result in a unit of greater mechanical stability with less need for later maintenance, the initial cost will be greater. For this reason doing as much fabrication at the manufacturer's plant as possible has been standard practice. Lower short-circuit ratios and inertia constants are being used in current hydroelectric generators because of their reduced importance following from the radically improved clearing times provided by modern circuit breakers. Amortisseur windings are being adopted generally on hydroelectric salient-pole generators.

Large water wheel generators of current designs recirculate cooling air and have surface-type finned-tube air coolers to dissipate the losses. Several coolers are

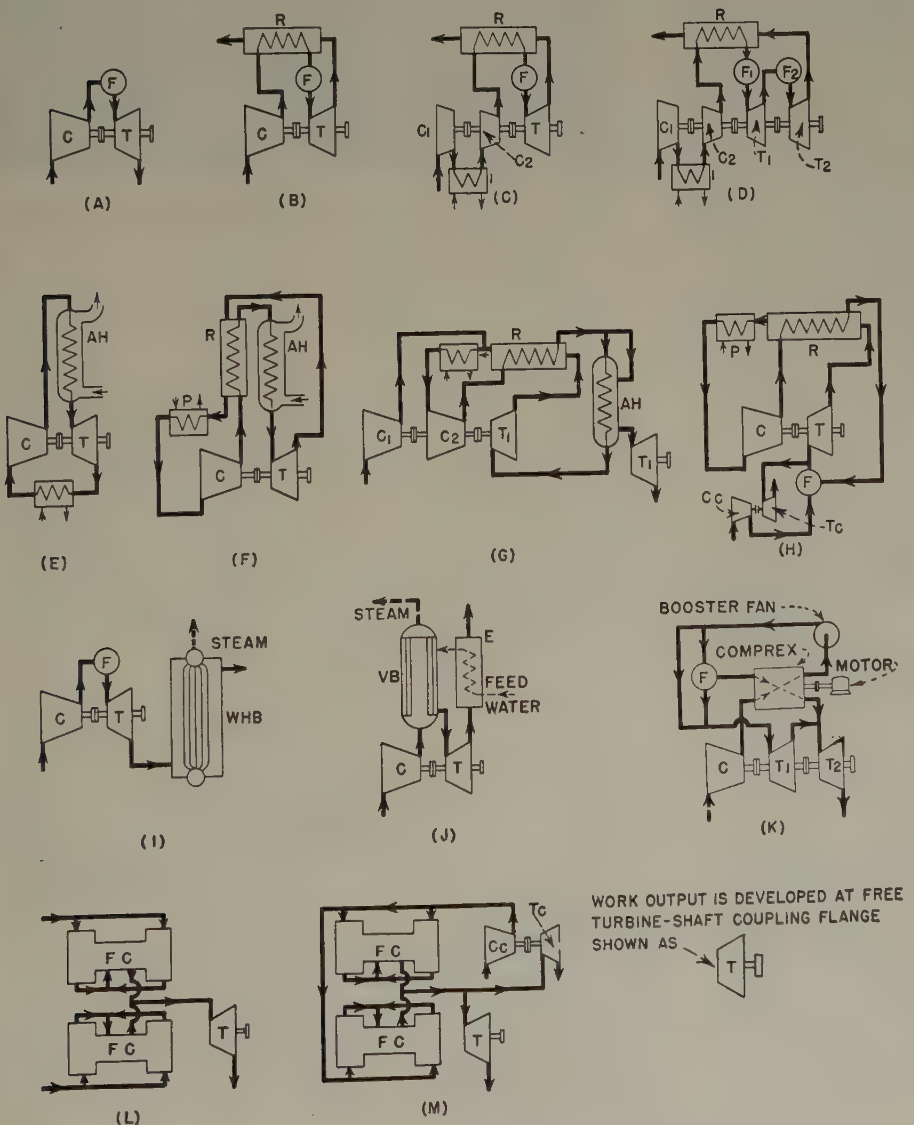

Figure 8. Gas-turbine cycles fall into many classes, some of the principal ones being shown here

Increased complexity results from attempting to realize higher efficiency, use higher gas temperatures with relatively low-temperature alloys, and attain utilization of all fuel types

A—Simple cycle
B—Regenerative cycle
C—Regenerative cycle with intercooled compressor
D—Regenerative cycle with intercooled compressor and reheating
E—Closed simple cycle
F—Closed regenerative cycle
G—Semiclosed regenerative cycle
H—Semiclosed regenerative cycle
I—Combination steam-gas cycle; waste heat boiler
J—Combination steam-gas cycle; Velox boiler
K—Cycle with compression unit
L—Free-piston-compressor cycle
M—Supercharged free piston compressor

AH—Air heater
C—Compressor
C_C—Charging compressor
E—Economizer
F—Furnace
FC—Free piston compressor
I—Intercooler
P—Precooler
R—Regenerator
T—Turbine
T_C—Charging turbine
VB—Velox boiler
WHB—Waste heat boiler

arranged symmetrically around the unit's outer periphery and enclosed in a light metal structure. This results in a unit of simple construction, with smooth lines, having a pleasing external appearance.

Much interest has been aroused in the newly developed silicone compounds. One application will be as insulating varnishes especially for high-temperature conditions. At this time applications have been to windings operating at 4,000 volts and less. It has been forecast that use of the silicone varnish will

1. Reduce electric equipment size and weight where operating temperature can be increased.
2. Greatly increase insulation life where conventional size, weight, and temperatures are maintained.
3. Permit operation in ambient temperatures above permissible limits for usual insulations.

As a result of emergencies during the war, a trend has developed in use of forced-circulation oil cooling for transformers. This permits increasing transformer ratings.

Rising war loads focussed attention on system interconnection and operation since other war demands on manufacturers building capacity made it difficult to get additional generating capacity installed. Principal interest centered on method of tie-line load control, frequency control, and prime mover governing.

A committee jointly sponsored by the AIEE and ASME was formed to promulgate prime mover speed governing specifications. Five specifications are being prepared, one for hydraulic turbines and four for steam turbines convering straight-condensing, back-pressure, and nonautomatic and automatic-extraction units. These are being prepared as separate specifications to facilitate their incorporation by reference in purchase specifications.

INTERNAL COMBUSTION ENGINES

Utilization of Diesel engines during the war increased many times, most applications being in the transportation field on land and sea. Since 1940 nearly every manufacturer of 4-cycle engines in the United States offers a supercharged engine having a marked increase in rating with considerable improvement in economy of fuel, space, and weight. Some basic-design engines with a few concurrent changes have had capacity increases as high as 100 per cent by employing supercharging.

Improvements have been effected in operating-safety devices such as over-speed governors, low-lubricating-oil pressure, over-temperature, loss-of-cooling-water warning, and shutdown apparatus. Pump capacities for lubricating oil and cooling water has been increased. Indirect-cooling systems have become nearly standard practice through the use of improved heat exchangers. Lubricating systems have been improved considerably by providing increased flow through the engine.

Fuel-injection equipment now is built wholly in the United States. Improvements in this apparatus in some instances have been effected through designs based on improved workmanship where tolerances are measured in millionths of an inch instead of in thousandths.

No tendency is evident here today to build low-speed Diesel engines in excess of 7,500 horsepower. In contrast, some engines with ratings in excess of 20,000 horsepower were built some years ago in Europe.

Largest installation of internal-combustion engines was made for an aluminum reduction plant at Jones Mills, Ark. Construction started March 1942 and was completed June 1943. First units went into service November 1942. This plant has 68 units installed totalling 78,000 kw capacity. These consist of 18 2,250-kw dual-fuel Diesel engines and 50 750-kw convertible gas engines. Fuel used was natural gas from northern Louisiana and southern Arkansas. Pilot oil equalling about 5 per cent of total fuel input was used to stabilize combustion. These engines supplied two aluminum pot-lines having a peak demand of 67,000 kw and an annual load factor of 94 per cent.

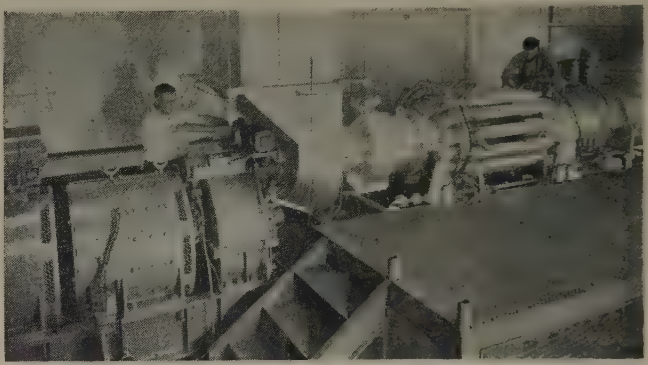

Figure 9. A 2,000-horsepower simple-cycle experimental gas turbine on test floor of Westinghouse Electric Company uses 1,350-degree-Fahrenheit inlet gas temperature

Left to right, double-armature d-c generator, reduction gear, inlet hood, axial compressor, 12 combustion chambers, gas turbine, and exhaust diffuser

GAS TURBINES

Since 1939 considerable progress has been realized in the development of the gas turbine as a prime power producer. Gas turbines have been applied with signal success in the aeronautical field to both jet-propelled and propeller-driven craft. A gas turbine locomotive has been in operation in Europe since 1941 whenever oil fuel was available. A large number of gas turbines have been used abroad for supercharging Velox boiler furnaces and more than 30 units have been in operation here from 3 to 10 years in the Houdry catalytic cracking process. During the war thousands of superchargers were used on aircraft reciprocating engines here and abroad, the power for these units being developed by gas turbines operating on the engine exhaust gas. A stand-by gas turbine generating plant has been in operation in Switzerland since 1939.

Many schemes have been proposed and are under experimentation for practical gas turbine cycle arrangements. The United States Navy has sponsored the building of several experimental units of different designs for ship propulsion. With high-efficiency turbines and compressors, which are the principal working elements of the cycle, the turbine inlet gas temperature is the principal controlling element in achieving high cycle thermal efficiency. To utilize such high temperatures, new metal alloys were developed and they are still the subject of intensive research to push temperature utilization as high as possible. Some units have been built for 1,250 degrees Fahrenheit; one has been built for 1,500 degrees Fahrenheit with special blade cooling provisions; several units are under construction to operate at 1,350 degrees Fahrenheit without blade cooling. Higher gas temperatures are used on military aircraft gas turbines where short engine life can be tolerated.

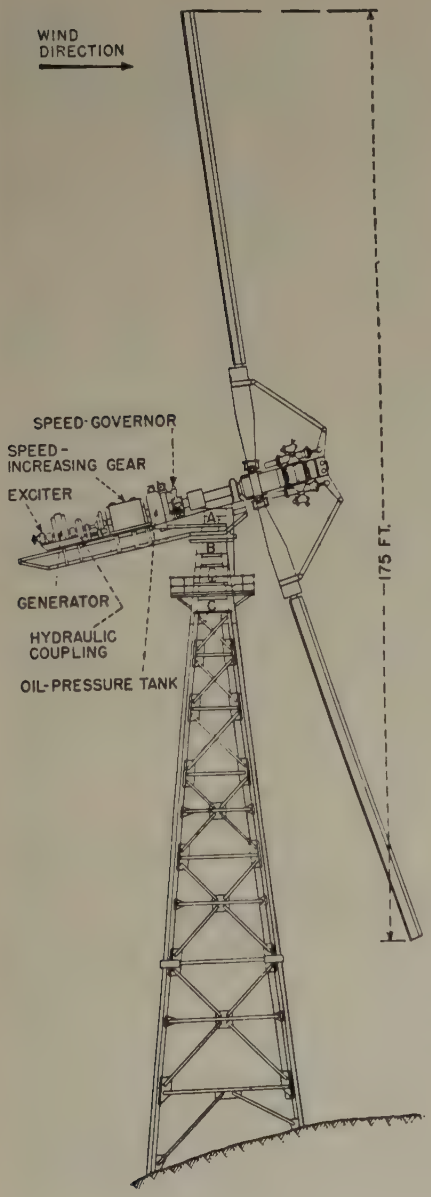

Figure 10. A 1000-kw wind turbine on top of Grandpa's Knob near Rutland, Vt., was the first wind-driven unit to deliver power into a utility system

Increased thermal efficiency also can be achieved by using regenerators which recover part of the exhaust gas heat energy to preheat the compressed air before it enters the furnace or combustion chamber. Intercooling the air during compression reduces compressor work requirements and raises cycle thermal efficiency. A third method of increasing efficiency expands the hot gas partially through the turbine and then reheats it before completely expanding it to atmospheric pressure. All of these refinements have been used in various units constructed for experimentation or commercial use.

Switzerland produced two other methods of achieving high thermal efficiency as represented by the power-gas generator or free-piston compressor and the Comprex. These are distinguished by their utilization of high gas temperatures without calling for special metal alloys in construction of the cycle components (during the war high-temperature alloys were unavailable to the Swiss). The free-piston compressor serves as both the furnace and compressor and is a reciprocating engine in effect. Here the high-temperature gas produced in the Diesel cylinder (furnace) acts directly upon pistons which compress the air before introduction to the cylinder. The gas exhausted from the unit is at relatively high pressure and temperature and produces the cycle power output by expansion through a gas turbine. Several United States manufacturers now are doing development work on this type unit.

In the Comprex unit, an entirely new invention, a pneumatic ram principle is utilized. It uses hot charges of relatively high-pressure gas from the furnace to do compression work on partially compressed air discharged from a conventional axial flow compressor; the gas and air charges are in direct contact in this device.

Because the furnace combustion products pass directly through the turbine in all open cycles it is evident that oil and gas are the ideal fuels. However, coal is the more abundant and often cheaper fuel and hence much effort has been and is being exerted to adapt it as the gas turbine energy source. Several proposals and two actual experimental units use a closed-cycle system where the working medium to be heated is separated from the furnace and combustion process by heat transfer surfaces as in a steam boiler. Coal burning presents no problem in these designs. Further investment gains are made by maintaining the lowest working air pressure in the cycle above atmospheric at about 85 pounds per square inch gauge. This brings the size of the rotating elements down very markedly. However these advantages are offset by the large amount of expensive high-temperature alloys that must be used in construction of the air heater.

Development of the closed-cycle plant is taking place in Switzerland. In the United States intensive research is devoted to burning pulverized coal in open-cycle plants where combustion products pass through the turbine. Several methods are being investigated, one works on the principle of separating fly ash from the gas prior to passing it through the turbine, and another on superfine pulverization of the coal prior to burning. Separation occurs in the first method by passing the combustion products from the furnace through a battery of small cyclone-type mechanical separators. Experiments have shown that about 95 per cent of the solids are removed from the gas stream at the expense of about one pound drop in gas pressure. The remaining 5 per cent of dust passing through the turbine is of less than 5-micron diameter and research indicates that dust of this size has no deleterious effect on turbine blading.

The second method of superfine coal pulverization makes all fly ash particles produced in the furnace combustion process of less than 5-micron diameter Then all this dust can be passed through the turbine without separation from the gas.

Two gas turbine locomotives designed for pulverized coal burning with ash separation are now under construction in the United States for the locomotive development committee of Bituminous Research, Inc.

In contrast with steam plant practice, gas turbine size has to be several times larger than the net plant output, as the compressor needs about 60 to 80 per cent of the turbine output to do its compression work. This factor, coupled with the wide gas temperature variation that the gas turbine must work under, places limitations on the maximum unit size that can be built. For a while 10,000 kw was regarded as the maximum capacity for open cycle units, with no definite limitations on closed cycle units because of their small physical size. However, a 27,000-kw open-cycle unit is now under construction in Switzerland.

Cycle thermal efficiency varying from 18 to 31.5 per cent has been reported on tests of various gas turbines. These efficiencies are based on the fuel lower heating values. The lower thermal efficiency is representative of simple units without regenerators, intercooling, or reheating. Studies indicate that with all of these devices and a 1,500-degree-Fahrenheit gas temperature, cycle thermal efficiencies of about 40 per cent might be realized.

Several central station utilities in the United States have studied application of gas turbine units to their systems but to date no installation proposals have been reported.

WIND TURBINE

The first serious attempt at generating electric energy on a commercial scale from the wind as a source of energy was made during this period. On October 19, 1941, a wind turbine installed on top of Grandpa's Knob, near Rutland, Vt., was the first wind-driven device to deliver a-c electric power into a utility system, the Central Vermont Public Service Corporation. This unit, Figure 10, had a capacity of 1,000 kw and was mounted on top of a structural steel tower 110 feet high and 36 feet square at the base.

A heavy plate-steel-girder structure, called a pintle girder, formed the plant mounting atop the tower. This girder inclines downward into the wind with a 12.5-degree slope from the horizontal and is supported at *A* on the top end of a pintle shaft. This shaft has a double roller guide bearing just below the girder at *B* and a combination roller guide and thrust bearing at *C* which allows the whole plant to yaw (swing) with the wind.

The blades and their control mechanism overhang one side of the tower and almost balance the rest of the equipment. The blades constructed of shot-welded stainless steel are more than 11 feet wide and 65 feet long, weighing 15,300 pounds each. Four motions are provided for the blades: rotation, yawing, pitching, and coning. Rotation, which produced the energy, took place at 28.7 rpm with a blade-tip speed of 15,785 feet per minute. The whole plant assembly yawed with the wind by the aid of gearing just below the pintle girder. Gear motion was controlled automatically by a yaw meter or wind-direction vane.

As the a-c generator requires constant-speed drive and wind velocities are variable, the blades were provided with variable-pitching adjustment to maintain constant shaft speed. Rotation would start with a wind speed of four miles per hour but power generation would start only at speeds about 18 miles per hour. At wind velocities greater than 60 miles per hour the unit would be taken out of service.

When the blades are being driven at normal speed, centrifugal force holds them at nearly right angles to the main shaft. If a sudden gust of wind hits them they can cone down-wind to a maximum of 20 degrees to relieve the initial shock and assist the governor in regulating speed. The governor regulates speed by automatically changing the blade pitch angle. For normal operation, pitch angle changes of 30 degrees would be needed, but this unit had a 99-degree range for research purposes.

The 1,000-kw generator was built for 600-rpm 80-per-cent-power-factor 2,300-volt, 60-cycle 3-phase operation. Generator leads go down through the pintle shaft center and connect to slip rings. Brushes on these slip rings connect to cables tying the generator into the 44,000-volt transmission system of the utility through a transformer.

The unit first went on test October 19, 1941, and remained so for a little over a year until February 20, 1943, during which time it had operated on the line for 695 hours and 192 hours off the line on test, generating a total of 298,240 kilowatt-hours. At the end of this period the main-shaft bearing failed and, because of priority conditions, could not be replaced until March 3, 1945.

Between March 3 and 26, 1945, the unit operated as a routine generating station of the system for 143 hours, producing 61,780 kilowatt-hours. This period was an unusual windless three weeks for March. During a smooth 20-mile-per-hour wind on the latter date one of the blades failed at the outboard edge of the bolted shank spar connection. Failure was caused by multiple corroded cracks at this point. The broken-off blade landed about 1,000 feet away on the mountain side, the remaining blade was damaged by coning negatively and colliding with the tower structure. Similar corroded cracks were found at the same location on the latter blade. The age of the corrosion was unknown.

A redesigned 1,500-kw wind turbine will be erected on a high summit in the Green Mountains of Vermont to feed again into a utility system. Wind-power plants always must operate in parallel with another source of power, such as water-power plant with storage or a steam plant. Studies indicated that in any one year a wind-power plant can generate more kilowatt-hours than most water-power plants because average wind conditions remain more stable from year to year than average water conditions.

Another interesting proposal has been made for wind turbines of 6,500- and 7,500-kw capacities. Instead of attempting to maintain constant blade speed this design

Table II. Hydroelectric Projects Constructed, Operated, and Projected by Government Agencies

Project	States	River	Ultimate Capacity, Hp	Initial Capacity, Hp	Installed Capacity, Hp	Capacity on Order, Hp
United States Bureau of Reclamation						
Grand Coulee	Wash.	Columbia	2,877,000	478,000	928,000	945,000
Anderson Ranch	Idaho	Boise	55,500	37,000		37,000
Minidoke	Idaho	Snake	26,500	9,000	19,500	
Shasta	Calif.	Sacramento	522,000	419,000	419,000	103,000
Keswick	Calif.	Sacramento	102,000	102,000		102,000
Parker Dam	Ariz., Calif.	Colorado	160,000	120,000	160,000	
Davis Dam	Ariz., Calif.	Colorado	311,000	311,000		311,000
Hoover Dam	Ariz., Nev.	Colorado	1,835,000	522,000	1,435,000	
Elephant Butte	N. Mex.	Rio Grande	34,500	34,500	34,500	
Green Mountain	Colo.	Blue	30,000	30,000	30,000	
Estes	Colo.	Big Thompson	63,000	63,000		63,000
Mary's Lake	Colo.	Big Thomspon	11,300	11,300		11,300
Kortes	Wyo.	North Platte	55,500	55,500		55,500
Shoshone	Wyo.	Shoshone	20,000	20,000	20,000	
Heart Mountain	Wyo.	Shoshone	8,300	8,300		8,300
Boysen	Wyo.	Big Horn	21,000	21,000		21,000
Seminoe	Wyo.	North Platte	45,000	45,000	45,000	
United States Engineers Corps						
Bonneville	Oreg., Wash	Columbia	729,000	137,000	729,000	
Fort Peck	Mont.	Missouri	150,000	70,000	70,000	
St. Marys Falls	Mich.	St Marys	23,925	23,925		23,920
Norfolk	Ark.	North Fork	168,000	42,000	42,000	42,000
Narrows	Ark.	Little Missouri	36,000	24,000		
Fort Gibson	Okla.	Grand	120,000	80,000		80,000
Dennison Dam	Okla., Tex.	Red	283,000	59,080	59,080	56,000
Wolf Creek	Ky.	Cumberland	414,000	207,000		207,000
Central Hill	Tenn.	Carney Fork	207,000	138,000		138,000
Dale Hollow	Tenn.	Obey	75,000	50,000		50,000
Allatoona	Ga.	Etowah	152,900	102,900		102,900
Imperial Irrigation District						
Drop 3	Calif.	All American Canal	15,000	7,500	7,500	
Drop 4	Calif.	All American Canal	26,600	13,300	13,300	
Platte Valley Public Power and Irrigation District						
Sutherland	Nebr.	North Platte	35,000	35,000	35,000	
Loup River Public Power District						
Monroe	Nebr.	Loup	9,600	9,600	9,600	
Columbus	Nebr.	Loup	54,000	54,000	54,000	
Central Nebraska Public Power and Irrigation District						
Jeffrey Canyon	Nebr.	Platte	26,000	26,000	26,000	
Johnson 1	Nebr.	Platte	26,000	26,000	26,000	
Johnson 2	Nebr.	Platte	50,000	25,000	25,000	
Grand River Dam Authority						
Pensacola Dam	Okla.	Grand	100,000	80,000	100,000	
Lower Colorado River Authority						
Buchanan Dam	Tex.	Colorado	51,900	34,600	34,600	
Tom Miller	Tex.	Colorado	20,000	20,000	20,000	
Inks Dam	Tex.	Colorado	16,000	16,000	16,000	
Marshall Ford	Tex.	Colorado	90,000	90,000	90,000	
Brazos River Conservation and Reclamation District						
Possum Kingdom	Tex.	Brazos	51,000	34,000	34,000	
South Carolina Public Service Authority						
Santee-Cooper	S. C.	Santee	213,000	173,000	173,000	
Greenwood County Board of Commissioners						
Buzzards	S. C.	Saluda	30,000	22,200	22,200	
Tennessee Valley Authority						
Kentucky	Ky.	Tennessee	220,000	176,000	176,000	44,000
Pickwick	Tenn.	Tennessee	288,000	96,000	192,000	
Wilson	Ala.	Tennessee	610,000	206,000	470,000	
Wheeler	Ala.	Tennessee	360,000	90,000	180,000	90,000
Guntersville	Ala.	Tennessee	136,000	102,000	102,000	
Hales Bar	Tenn.	Tennessee	44,000	44,000	44,000	
Chickamauga	Tenn.	Tennessee	144,000	108,000	108,000	
Watts Bar	Tenn.	Tennessee	210,000	126,000	210,000	
Norris	Tenn.	Clinch	132,000	132,000	132,000	
Fort Loudoun	Tenn.	Tennessee	176,000	88,000	88,000	88,000
Cherokee	Tenn.	Holston	166,000	83,000	83,000	
Douglas	Tenn.	French Board	166,000	83,000	83,000	41,500
South Holston	Tenn.	South Holston	41,000	41,500		
Watauga	Tenn.	Watauga	69,000	69,000		69,000
Fontana	N. C.	Little Tennessee	274,000	183,000	183,000	
Apalachia	Tenn.	Hiwassee	106,000	106,000	106,000	
Hiwasee	N. C.	Hiwassee	160,000	80,000	80,000	
Chatuge	N. C.	Hiwassee	10,700	10,700		
Nottely	Ga.	Nottely	13,400	13,400		
Ocoee 3	Tenn.	Ocoee	33,500	33,500	33,500	
Total Capacity			12,706,225		6,947,780	2,689,420

uses a variable speed d-c generator and connects to the a-c transmission system through a rotary converter. The generating equipment in this scheme would be mounted on top of a 475-foot tower.

NUCLEAR ENERGY

Large scale release of energy from the atomic nucleus is the outstanding scientific achievement realized during World War II. This new means of energy production places itself squarely in the field of power generation for possible future utilization. However, the radioactive features of this process impose formidable problems of control, design, and waste disposal which long may delay practical economic application to power production. While producing plutonium and uranium 235 is an involved process it appears that this will represent only a very minor element of cost in power production utilization.

Energy can be obtained from transmutation of elements either by combining two light elements into one of intermediate weight or by breaking up a heavy element into two or more elements of intermediate weight. The atomic bomb utilizes the latter process. Theoretically, 11,400,000 kilowatt-hours of energy can be obtained by fission of one pound of uranium 235. This energy appears as heat, which immediately suggests using it as a source for steam generation or power generation by gas turbines or for process heating.

Four laboratories will engage in nuclear research under the direction of the Manhattan District:

1. Clinton Laboratory at Oak Ridge, Tenn.
2. Argonne National Laboratory at Chicago, Ill.
3. Brookhaven National Laboratory on Long Island, N. Y.
4. Knolls Atomic-Power Laboratory at Schenectady, N. Y.

All of these organizations will work on the problem of atomic-produced power.

The power-pile program at Oak Ridge has progressed to the point of putting together the preliminary design. Problems being worked on are actual size and shape of "fuel" unit (pile), method of transferring heat from pile to engine or prime mover, method of loading and unloading pile, automatic pile control, and shielding against radiation. Emphasis will be laid on realizing a heat source of long life and great reliability. This is of great importance because the radioactivity makes any pile, once operating, difficult and dangerous to shut down for maintenance. Initial pile operation will be to provide heat energy for steam electric generation operating at conventional central station temperature ranging from 650 to 940 degrees Fahrenheit.

No capacity has been set as yet for the pilot plant. It is possible that all equipment will be conventional from the boiler through the generator. None of the equipment has been ordered at this writing.

Pile construction materials must have strength and rigidity at high temperature and not break down under neutron bombardment. The material serving as a moderator (carbon, heavy water) must have the proper neutron slowing qualities, yet be able to withstand pile operating temperatures. Selecting a suitable heat-transfer fluid from a range of possibilities including

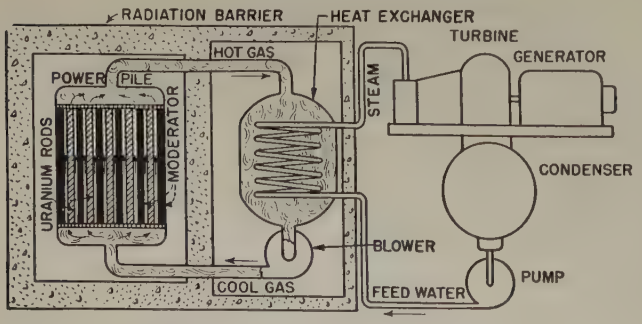

Figure 11. Simplified conception of how nuclear energy can be used as a source for a steam-electric station

Several government-sponsored projects are under way to develop nuclear-energy power plants

Table III. Growth in Power Production

Generating Capacity of Major Plants Contributing to Public Supply in Kilowatts, Excluding Certain Mining and Manufacturing Plants and Railroad Plants

Year	Steam	Hydro	Internal Combustion	Total
1920	8,919,727	3,703,531	90,350	12,713,608
1930	23,385,522	8,585,164	413,677	32,384,363
1940*	28,374,957	11,223,729	928,195	40,536,881
1941	30,209,285	11,817,374	988,777	43,015,436
1942	31,778,567	12,841,933	1,042,450	45,662,950
1943	33,624,581	13,883,583	1,052,603	48,560,767
1944	34,150,807	14,586,324	1,061,941	49,799,072
1945	34,036,609	14,987,547	1,078,286	50,102,442
1946	34,304,910	14,849,036	1,149,714	50,303,660

* Years 1940–44 include New York, N. Y., rapid transit system central stations. To make series continuous, subtract about 600,000 kw from capacity for years 1940–44 in both steam and total columns.

Table IV. Growth in Power Production

Generation of Major Plants Contributing to the Public Supply in Million Kilowatt-Hour, Excluding Certain Mining and Manufacturing Plants and Railroad Plants

Year	Steam	Hydro	Internal Combustion	Total
1920	23,488	15,760	156	39,404
1930	59,293	31,190	629	91,112
1940*	93,918	47,321	1,514	142,753
1941	114,037	50,563	1,606	166,206
1942	122,184	63,871	1,630	187,685
1943	144,013	73,632	1,746	219,391
1944	153,905	73,945	1,916	229,766
1945	140,437	79,917	2,080	222,434
1946	142,380	78,397	2,352	223,129

* Years 1940–44 include New York, N. Y., rapid transit systems central stations To make series continuous, subtract about 900,000,000 kilowatt-hours in 1940 graduated up to about 1,500,000,000 kilowatt-hours in 1944 in both steam and total columns.

ordinary water, heavy water, and other liquids gases, and molten metals constitutes a major problem.

Because of radioactivity the pile enclosure cannot be entered for repairs without a very extended shutdown period to allow the radiations to dissipate themselves. Hence the pile and associated equipment—pumps, blowers, valves, and heat exchangers—all of which will be radioactive during operation, must possess extraordinary reliability. Even in the smallest plants both the pile and heat exchanger must be shielded by massive walls of concrete or heavy material to protect personnel.

In contrast to the unfortunate popular furor produced by irresponsible prognosticators, stands the fact that atomic energy is not synonomous with free energy. At the present time plant investment requirements appear to be of such magnitude as to burden the atomic power plant with very heavy fixed charges and certainly the raw energy will not be "free" whatever form it may take eventually. One published estimate states that atomic plants of 500,000-kw capacity and greater appear to produce electric energy that is competitive with coal and hydro-produced energy. Obviously the economic opportunity to apply plants of this size will be rare at the present time.

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306. The Economics of Atomic Power, **P. W. Swain.** *Power* (New York, N. Y.), volume 90, June 1946, pages 76–8.

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ABSTRACTS... OF AIEE TECHNICAL PROGRAM PAPERS

TECHNICAL PAPERS previewed in this section will be presented at the AIEE winter general meeting, Pittsburgh, Pa., January 26–30, 1948, and will be distributed in advance pamphlet form as soon as they become available. Members may obtain copies by mail from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y., at prices indicated with the abstracts; or at five cents less per copy if purchased at AIEE headquarters or at the meeting registration desk. Prices of copies to nonmembers will be twice those for members, less five cents for mailed copies.

MAIL ORDERS will be filled as pamphlets become available.

ABSTRACTS are prepared by the authors of the papers and approved by the technical program committee.

Basic Sciences

48-1-ACO—A Critical Analysis of Voltage Conventions and Double-Subscript Notations; *Myril B. Reed (M '43), W. A. Lewis (M '45). 25 cents.* Great confusion in electrical engineering literature is caused by the lack of a uniform convention in designating voltages or potential differences. The difficulties are most apparent when double subscripts are appended to the voltage symbol but exist also when single subscripts are used. In this paper, the four different conventions in accepted use are analyzed and compared. The probable source of the difficulty is described and suggestions for improvements based upon voltage polarity rather than voltage direction are included. A possible set of standards is offered for consideration.

48-58—Hystero-Viscosity in Silicone; *Michel G. Malti (M '45), A. K. Chatterjee. 25 cents.* Hystero-viscosity loss is a term applied to the energy loss due to the combined effects of hysteresis and viscosity in dielectrics. This loss varies with the nature of the dielectric, its temperature, the period of charge or discharge, the interval between successive charges, the presence of ionizing radiations, the mechanical pressure exerted, and the maximum electric pressure impressed on the dielectric. The authors study the effect on hystero-viscosity loss, of the period of charge or discharge, of the interval between successive charges, and of the maximum impressed electrical pressure on silicone resin. It is found that:

$$w=aE_m^2(1-\epsilon^{-bt_i})\epsilon^{-c(t_p-T_0)^2} \qquad (1)$$

where w is the hystero-viscosity loss, a, b, c, T_0 are constants of the material, E_m is the maximum impressed voltage, t_p and t_i are, respectively, the period of charge or discharge and the interval between successive charges or discharges. Values computed from relation 1 are checked with experimental values and show close agreement.

48-68—Attenuator Materials, Attenuators, and Terminations for Microwaves; *G. K. Teal, M. D. Rigterink, C. J. Frosch. 35 cents.* Attenuator materials, attenuators, and terminations were developed to meet a variety of communication and radar needs, the most important of these being the absorption of high powers. Consideration had to be given to the magnitude and range of attenuation obtainable in a given material, its dependence on ambient temperature and frequency, the reflection of microwave radiation, minimization of moisture absorption, chemical and geometrical stability, heat conductivity, and adaptability to compact designs. The requirements for specific jobs were met best by developing materials of several kinds: high loss dielectrics of ceramic, plastic, and rubber materials, and heat resisting resistor strips. The difficulty of determining the dielectric constants of high loss solids and the complexity of taper theory required empirical investigation of the shape factor to permit the attainment of designs having the desired attenuation and low reflection. Data relating to the material and design factors with the operating characteristics of the microwave devices were obtained.

48-69—Insulation Breakdown as a Function of Area; *L. R. Hill (M '46), P. L. Schmidt (A '47). 20 cents.* It is found in practice that large areas of insulation have a lower average breakdown voltage and less variability than small areas of the same insulation. This paper applies probability theory to give a theoretical explanation of this phenomenon on the basis of insulation variability, excluding electrode edge and contact effects. General expressions are derived from which tables and curves are calculated for rapid and easy translation from a distribution of an elemental area to that of n areas of insulation in parallel.

48-70—Solutions of the Mathieu Equation; *Harry J. Gray, Richard Merwin (A '46), J. G. Brainerd (F '47). 30 cents.* The primary purpose of the paper is to present a moderately extensive set of tables of a new function, namely the function which satisfies the equation known to mathematicians as Mathieu's equation. It is substantially the result of analyzing the simplest case of a time-varying parameter circuit which readily can be set up. The equation also appears in certain problems of machinery, tube circuits, and so forth. In addition, it has relatively wide applications in fields outside electrical engineering, and a number of groups have been working on the solutions of the equation. Mathieu's equation is

$$\frac{d^2y}{dt^2}+\epsilon(1+k\cos t)y=0$$

and solutions are tabulated for $\epsilon=0(1)10$ and $k=0\ (0.1)\ 1$ over the range $0\leqq t\leqq\pi$. Each solution consists of two parts, one for initial conditions $y=1, y'=0$ and one for $y=0$, $y'=1$. The characteristic exponent and one other quantity necessary to extend the solutions beyond $t=\pi$ are given for each ϵ,k pair. The tables were obtained on the Electronic Numerical Integrator and Computer, and some 7,500,000 multiplications as well as a much larger number of additions and subtractions, were required.

Capacitors

48-55—10,000-Kva Series Capacitor Improves Voltage on 66-Kv Line Supplying Large Electric Furnace Load; *B. M. Jones (F '42), J. M. Arthur (A '45), A. A. Johnson (M '44), C. M. Stearns. 25 cents.* A 10,000-kva series capacitor recently installed on a 14-mile 66-kv line is operating successfully to improve voltage regulation and reduce voltage flicker at the 11-kv bus of a large steel mill, and along the 66-kv line. The mill load consists of 4 10,000-kva 3-phase electric arc furnaces and about 14,000 horsepower of synchronous and induction motors. The largest motor is a 4,000-horsepower 514-rpm wound-rotor induction motor on a motor generator set, equipped with a liquid rheostat for starting and for load control. This paper presents the planning and calculations for the application, a general description of the series capacitor and its associated devices, a discussion of the application problems, and the results of actual testing. Companion papers cover the design and protection of the capacitor and the design and layout of the capacitor substation. Tests were conducted to determine whether the 4,000-horsepower motor "self-excites." The results indicated that a shunting resistor around the capacitor is necessary to prevent this phenomenon. However, a shunting resistor of somewhat larger ohmic value is permissible than was determined by calculations. Motor hunting of lightly loaded synchronous motors was not expected and none occurred during the tests nor since the capacitor was placed in service. Line energizing tests with transformer exciting current only (54,000-kva bank capacity) with the capacitor in service were satisfactory. The voltage drop at the 11-kv customer's bus between no load and full load on the line with the capacitor in service is reduced more than half, a reduction of 12 volts on a 110-volt base. Also, the violent voltage fluctuations caused by arc furnace operation are reduced materially.

48-56—Design and Layout of 66-Kv 10,000-Kva Series Capacitor Substation; *G. B Miller (M '46). 20 cents.* Describes the design and layout problems encountered in the construction of a substation for the largest series capacitor in operation to date. So far as known, it is the highest voltage use of a series capacitor. The purpose of the installation is to alleviate voltage flicker and improve voltage regulation at a large steel mill, where the load is approximately 40,000 kva. Electric arc furnaces are the principal load and source of the flicker. Other major load consists of large synchronous motor generator sets and a 4,000-horsepower wound-rotor motor. Principal sections of the paper cover: brief description of equipment, substation site and arrangement of equipment, switching equipment, safety to personnel, station impulse level. Line drawings are included to illustrate the equipment. Photographs show the equipment and substation arrangement. Companion papers cover the application and design and protection of the series capacitor.

48-57—Design and Protection of 10,000-Kva Series Capacitor for 66-Kv Transmission Line; *A. A. Johnson (M '44), R. E. Marbury (F '45), J. M. Arthur (A '45). 20 cents.* This paper describes the design of a 10,000-kva series capacitor for a 66-kv transmission line and the details of the associated protective devices. The series capacitor consists of 240 standard 15-kva 2,400-volt capacitor units per phase. These units are grouped 80 in parallel with three such groups in series giving a maximum correction of 7,200 volts per phase at a circuit current rating of 500 amperes. Each of the three groups of 80 capacitor units per phase is protected by a parallel gap which limits the voltage across the capacitors to approximately twice the normal voltage rating. In the event of a sustained arc across a gap, the current in the gap circuit initiates the closing of a thermally operated switch which by-passes both the gap and the capacitor units. After the thermal element cools the switch automatically opens, restoring the capacitor to the circuit. The series capacitor is shunted by a resistor to damp out resonance associated with the starting of motors. These motors are part of the load in the steel plant which is supplied by the 66-kv line. The minimum value of ohms for the resistor was predicted from calculations and the actual required value determined from staged tests. The capacitor housing and the resistor are insulated from ground by 69-kv insulators. The series capacitor and its protective equipment are independent of any external power source and operate automatically.

Communication

48-8—An Electro-Acoustical Locating System; *Eric A. Walker (M '41). 20 cents.* This paper describes an electro-acoustical locating system that is used principally for the location of lost torpedoes. A study of the various mechanisms for transmitting information through water is covered, showing why all systems, except acoustical, had to be discarded. The body of the paper concerns itself with the design of a nondirectional transmitter and electronic driving system, which is rugged, small, and light in weight; and can be installed in the body which might be lost. A directional receiving system which can be operated from a small vessel for searching is described. This includes the design of a receiving hydrophone with proper directivity, so that it is possible to scan the ocean in both azimuth and depth, and the construction of a selective receiver to reduce ambient noise.

48-59—Recent Improvements in Loading Apparatus for Telephone Cables; *S. G. Hale (M '46), A. L. Quinlan (M '45), J. E. Ranges. 30 cents.* Through the use of improved materials, new winding facilities, and manufacturing techniques, it has been possible to design new coils for loading exchange area cables which are equivalent electrically to the superseded types but require one-third less winding copper and have considerably reduced over-all dimensions. Similarly, 3-coil units for loading toll cables have been provided which are much smaller than their predecessors, with an accompanying 50 per cent reduction in both winding copper and core material requirements, obtained at the expense of a very moderate sacrifice in electrical characteristics. The reduced size of the new coils and units, together with improved assembly arrangements, made possible a reduction in volume and weight of the new coil and unit cases amounting to approximately 65 per cent.

48-60—A Telegraph Signal Analyzer; *G. L. Erickson (M '44). 20 cents.* The telegraph signal analyzer described by this paper is a very small, portable test set which serves to measure the distortion on start–stop telegraph circuits. An observation is made of every individual signal pulse as it is received, and the test results are in the form of a permanent record on a paper chart. This signal analyzer can be employed to determine the condition of a transmitting mechanism, check the operation of a receiving printer, or investigate the various components that make up the total distortion on a working circuit. It provides a simple means for determining the cause of any trouble with a degree of accuracy which is ample for field purposes. The theory and operation of the device are described, and a number of typical charts are included to illustrate the effect of various types of signal distortion.

48-61-ACO—Optical Radar for Surveying; *W. W. Hansen. 20 cents.* An instrument has been developed for surveying terrain by the use of radar techniques. The instrument transmits pulses of light from a flash lamp to a retrodirective reflector placed at the point whose position is to be determined. The light returning from the reflector falls on a photomultiplier whose output is amplified to produce a pip on a cathode-ray tube. Distance is measured by determining the transit time of the pulse of light. This is accomplished by auxiliary circuits which include a local crystal-controlled oscillator. These auxiliary circuits produce timing markers on the tube which can be made to match the pip produced by the returning light. Angles are measured with the scribed circles of a conventional transit. The angular position of a reflector is determined with considerable precision by orienting the transmitter–receiver unit to obtain a maximum return pip. The optical system makes use of a single parabolic searchlight mirror, the outer portion of which is used for the transmitted beam while the inner portion is used for the received beam. The whole equipment operates alternatively from storage batteries or from 110 volts alternating current. It is designed to be separable into several units for easy transportation.

48-74—Western Union Teletape Facsimile; *Leon G. Pollard. 20 cents.* This paper describes a simplified facsimile system which utilizes Western Union "teledeltos" dry recording paper in the form of tape for transmitting as well as receiving. A conductive method of pickup from ordinary lead pencil writing is employed in place of the usual optical and photoelectric cell system. Scanning and recording are accomplished by means of a multitipped rotating stylus which brushes lightly over the surface of the tape. One machine is used for the dual purpose of transmitting and receiving. Mechanical and circuit design features are discussed and the uses of such a system for intercommunication purposes over local lines is described.

48-75—Magnetic Recording Tapes; *Marvin Camras (A '41). 25 cents.* Paper or plastic tapes with magnetic coatings, as well as solid metal ribbons, have a wide field of use in magnetic recording. Magnetic properties, frequency response, signal-to-noise ratio, output level, sensitivity, and erasability of a number of different tapes are compared. A newly developed coated material has a balance of these properties making it especially suitable for high quality magnetic recording.

48-76—Turn-in-Gap Erase Head for Magnetic Recorders Providing Intense High-Frequency Fields; *D. E. Wiegand (A'42), R. E. Zenner. 20 cents.* A new erase head structure has been devised for use in magnetic recording. This new head provides, at reasonable power inputs, much more intense erasing fields than were possible previously and thus makes the use of higher coercivity media feasible. This head is excited by a single conductor in the erasing gap. The gap conductor is energized by a single turn secondary winding of a transformer. Greater efficiency is achieved through the resulting reduction in leakage fluxes. Also, improved thermal characteristics increase the power handling ability of this head.

48-77-ACO—The Practical Application of Supersonic Bias in Magnetic Recording; *H. A. Howell. 20 cents.* This paper deals with the practical application of high-frequency bias in magnetic recording. It is a semitechnical discussion of circuits and methods of obtaining optimum performance, particularly in the case of coated media. Frequency response curves are shown of various types of tapes. A brief description of magnetic materials used on coated media is given.

48-86—Crystal Filters Using Ethylene Diamine Tartrate in Place of Quartz; *E. S. Willis (A'45). 20 cents.* This paper describes a new type of crystal filter which is being used at widely distributed locations in the Bell System. These filters employ ethylene diamine tartrate (EDT) crystal units as elements and they were developed to replace the quartz-type filters because of the threatened scarcity of quartz imports. The performance characteristics of these filters are compared with those of the quartz filters. This paper shows that EDT-type filters also should find a field of application not covered by the quartz type.

48-87—Design and Performance of Ethylene Diamine Tartrate Crystal Units; *J. P. Griffin, E. S. Pennell. 20 cents.* An extended research program on synthetic piezoelectric minerals has resulted in the development and adoption of EDT crystals for use in carrier telephone system filters. The crystals are grown artificially. Some unusual physical properties of the crystalline material give rise to novelty in the processing methods and mechanical design of the units. Among the properties are anisotropic temperature coefficients of expansion, fragility, natural cleavages, and water solubility. Extensive testing has proved the units to be sufficiently rugged and stable to withstand normal shipping and use. Superior electrical properties of the EDT result in filters with wider pass bands and lower impedance levels than commercially attainable with quartz.

48-88—Growing Crystals of Ethylenediamine Tartrate; *A. C. Walker, G. T. Kohman. 20 cents.* The need for a synthetic piezoelectric crystal to relieve the critical quartz supply situation has resulted in the development by the Bell Telephone Laboratories of a new organic salt crystal, ethylenediamine tartrate, which is being used in place of quartz in telephone circuits. This crystal is grown from a supersaturated aqueous solution of its salt by an entirely new method known as the constant temperature process. It differs from previous methods used for growing large single crystals from solution, in that the solution saturated at one temperature continuously is fed into a crystallizer tank maintained at a slightly lower temperature, thus providing the supersaturation condition necessary for crystal growth. Further, the solution is circulated in such a manner that the partially impoverished mother liquor overflows from the growing tank back into the saturator where it is refortified and filtered. It then is heated and returned to the growing tank in such a way as to avoid the formation of undesirable crystal nucleuses. The paper contains a description of the new method which is now in commercial operation, together with a general discussion of some of the important principles involved in the successful growth of large single crystals of water soluble salts.

48-91—A 150-Kc Carrier System for Radio Relay Applications; *J. E. Boughtwood (A'41). 25 cents.* The projected use of microwave radio relay systems for telegraph communication necessitated the development of channelizing equipment to integrate such systems with the existing wire carrier plant. The paper describes a frequency-division 32 voice-band carrier terminal operating in the 4 to 147-kc range, and utilizing single-sideband carrier-suppressed transmission. Group modulators, employing crystal diode elements, are operated in tandem to reduce the required number of carrier frequencies and filter types to a minimum. A frequency stability adequate for the operation of frequency modulation telegraph channels is provided by a crystal-controlled carrier supply source. Circuit flexibility and economy of equipment is enhanced by a patching arrangement which permits voice bands to be handled either individually or in blocks of four.

48-92—Filters for a 150-Kc Carrier System; *R. C. Taylor (A'30). 25 cents.* A system of ladder-type filters is described which permits 32 good quality 3,000-cycle communication bands to be placed in a 150,000-cycle spectrum. Only conventional coil and capacitor components are used, but extensive use is made of ideal transformer equivalents and the less well-known *m*-derived filter sections to produce economical filter structures using a minimum of inductive elements. The design of a typical filter is described and the modifications required to permit paralleling outlined. The measured attenuations of representative filters are shown and a chart of design formulas and a method for using ideal transformers are presented. The resulting system is applicable to coaxial cable and radio beam circuits.

48-99—The Director for Automatic Telephone Switching Systems; *Arthur Bessey Smith (F'22). 35 cents.* Straightforward direct trunking between the offices of a multioffice telephone exchange has obvious advantages. But the complexity of modern cities and the expanding area in which it is advantageous to let subscribers dial for themselves has brought about much tandem trunking. At the same time, the use of a universal numbering system for all telephones in an area has been recognized as a valuable simplification for the subscriber. The user can dial the directory number anywhere without prefixes or other modifications. Tandem trunking and the universal numbering system oppose each other. To compose the conflict the "director" was invented and installed in London, England, and elsewhere. This paper describes general principles and some of the interesting details by which registration, translation, and sending are accomplished.

Domestic and Commercial Applications

48-93—The Heat Pump from the Utility's Point of View; *S. W. Andrews (A'41). 20 cents.* The heat pump, because of its coefficient of performance, opens the way for electrical service to compete with fuel for the house heating market and at the same time provide by means of a single unit summertime cooling as well. The paper compares performance of the heat pump and resistance heaters, describes possible sources of heat—air, ground, and water—and discusses advantages and limitations of each, and touches briefly on research being done under direction of the industry co-ordinating committee and matter of rates to be applied to heat pump installations.

48-95-ACO—Electric House-Heating Tests in Oregon; *W. L. Sharp, A. E. Opdenweyer (A'47). 30 cents.* During the last few years, electrical utility organizations in the Pacific Northwest have experienced a rapid growth in complete electric house-heating load. Except for a few heat-pump installations which have been installed recently, this load has been imposed entirely by resistance heating methods. Tests to develop the amount and characteristics of resistance house-heating load in the lower Willamette Valley area of Oregon, served by Portland General Electric Company, were made as a basis for rate studies and for future system design.

Electric Heating

48-10—FCC Diathermy Design for Low Harmonic Radiation and Good Frequency Stability; *E. W. Chapin, W. K.*

Roberts, M. C. Mobley, Jr. *20 cents.* For some years the problems of interference caused by radiation from medical diathermy and industrial heating devices have mounted steadily. The Federal Communications Commission in June 1947 adopted part 18 of the "Rules and Regulations," which had as its purpose the reduction of the interference through the assignment of frequency bands for such devices, and the specification of maximum field intensities for out-of-band radiations. To demonstrate that the requirements could be met without seriously increased cost, the Commission developed a diathermy machine. In this paper the general principles of design which make for frequency stability and low harmonic radiation are set forth, and it is pointed out that they are equally applicable to the design of industrial heating equipment.

48-17—Some Economic Aspects of Radio-Frequency Heating; *L. M. Duryee (M '42).* *35 cents.* This paper presents mathematical formulas and discussions which will guide in selection of generators or oscillators, from an economic angle. Also included is the mathematical solution of the question as to whether work coils should be supplied with shunt capacitors or whether the generators should be of a size to provide both reactive power and active power. Frequency selection also is investigated. The paper then presents detailed case histories of radio-frequency heating installations, including operating data on many products, showing unit cost of products processed in conventional ways compared with radio-frequency heating, in a dozen different industries. Cost curves for various sizes of oscillators showing economic data broken down into power cost, amortization cost, tube replacement cost, and total cost, are presented. Both induction and dielectric are discussed, and one of the most recent applications of radar frequencies to commercial cooking is covered. The conclusion is reached that radio-frequency heating, when applied to suitable products and properly engineered, can retire equipment investments in from one to two years.

Electronic Instruments

48-21—Electronic Circuits of a Supersonic Reflectoscope; *R. B. DeLano, Jr. (A '46).* *20 cents.* This paper describes and discusses the circuits of an echo-type supersonic flaw detection device. It is shown that it is possible to operate all the electronic circuits in an instrument of this type directly from a-c power without rectification, and a discussion of the problems involved and their solutions is given for each type of circuit. Particular attention is given to the problem of voltage regulation.

48-96—Oil Film Thickness Indicator for Journal Bearings; *M. L. Greenough.* *30 cents.* An instrument is described for measuring the radial thickness of lubricating oil film separating a rotating shaft from its bearing. Four distance-measuring elements mounted on the bearing provide electric signals proportional to film thickness at these locations. A cathode-ray tube fed with these signals gives a continuous indication of eccentricity, that is, the radial displacement of shaft center from bearing center. Provision is made for determination of radial clearance at any time during operation, permitting rapid determination of film thickness by subtracting eccentricity from clearance. The necessary vectorial subtraction is performed by manipulation of suitable scales on the cathode-ray tube face. The distance-sensitive elements, operating upon the principle of variation of mutual inductance with proximity of a conducting surface, are discussed in detail. Electronic circuit design and instrument performance also are treated.

Electronics

48-9—D-C Amplifier Stabilized for Zero and Gain; *A. J. Williams, Jr. (M '45), R. E. Tarpley (A '29), W. R. Clark (M '44).* *40 cents.* An electronic amplifier for d-c measurements is described in which the zero is stabilized by the use of a contact type of modulator vibrating at 60 cycles per second. The gain is stabilized, by over-all d-c feedback, to a small fraction of one per cent. Circuits and precautions are described which have been used to adapt this type of amplifier to the measurement of contact potential drop, thermocouple electromotive force for infrared gas analysis, electromotive force of glass electrodes for pH determination, and current from capacitors resulting from leakage and absorbed charge. The relation between noise from thermal agitation and the system response is discussed.

48-32—Quadrature Operation of Filamentary Thermionic Gas Tubes; *V. L. Holdaway (A '31).* *20 cents.* This paper evaluates the nonuniformity of filament temperature resulting from the conduction of anode current in a thermionic gas-filled rectifier tube. Filament temperature changes, as a function of anode current, are shown for three circuit connections employing inphase filament excitation and for quadrature excitation. By operating the tube with the anode and filament voltage in quadrature, approximately double the value of current permissible under the inphase operating condition may be conducted before the same temperature difference results.

48-33—A Method for the Measurement of the Deionization and Ionization Times of Thyratron Tubes; *Milton Birnbaum.* *25 cents.* A technique for measurement of deionization and ionization times of thyratron tubes is described. Deionization-time curves are given for thyratron tube types 884, 2050, and 2D21. Deionization-time curves are plotted which show the effects of variation of the peak current, plate voltage after ignition, grid resistance, control grid bias, control grid and shield grid biases, and ambient temperature for the 2050 thyratron tube type and the effects of variation of peak current and ambient temperature for the 2D21 thyratron tube type. Ionization-time curves for thyratron tubes types 2A4, 2C4, 884, 6D4, 2050, 2D21, and 3C45 for two values of plate voltage are given.

48-34—Printed Circuit Developments; *Cledo Brunetti.* *40 cents.* Over the past two years, there has been an intense worldwide interest in means of wiring electronic circuits by simple mechanized processes, leading to lower manufacturing costs and reduced physical dimensions of electronic assemblies. Much of the work done along these lines resulted in the development of techniques which have become known as printed circuit processes. A general symposium was held in Washington on October 15, 1947, to facilitate rapid dissemination of current knowledge relating to printed circuits. Speakers representing research, industrial, and government agencies were invited to describe the results of their work before a group of 800 engineers. The highlights of those papers are presented.

48-35—Performance of Pumped Ignitron Rectifiers; *C. C. Herskind (M '40), E. J. Remscheid (M '40).* *20 cents.* This paper describes the over-all performance of pumped ignitron rectifiers as evaluated from the experience obtained on a large number of installations in electrochemical, railway, and industrial service. It covers the operation of the rectifier and its immediate auxiliaries such as evacuating, temperature regulating, and excitation equipment. The prime factors entering into rectifier performance from an operating point of view are discussed. Records covering arc-back frequency, ignitor life, and reconditioning are presented and provide the basis for conclusions as regards the grade of performance which may be expected.

Industrial Control

48-11—Improvements in Rolling Mill Preset Screw-down Controllers; *J. D. Leitch (M '42), C. A. Schurr (A '47).* *20 cents.* The automatic preset screw-down controller using differentially driven control elements first described in *The Iron and Steel Engineer* in 1933 has found considerable favor in the control of plate mills in the brass, aluminum, and steel industries. There has been some demand for increase in speed without loss in accuracy. Any attempt to increase the speed of roll movements introduces difficulties in stopping accurately at any prescheduled position. The use of electronic balance detectors and anticipators in place of contact making ammeters permits higher speeds without loss of accuracy. The anticipators introduce slow-down circuits prior to stopping and can be adjusted readily to compensate for changes in roll inertia and friction. A new system of schedule panels using plugs rather than patch cords simplifies prescheduling. Freedom from the complicated network of cords makes the set-up procedure more rapid and certain.

48-98—The Liquid Rheostat for Speed Control of Wound-Rotor Induction Motors; *G. L. McFarland (M'46), William Alvarez. 25 cents.* The widest application of liquid rheostats is for acceleration and speed adjustment of wound-rotor induction motors. Modern wind tunnel drives, centrifugal pump and fan drives, and steel mill roll drives are among those depending upon the liquid rheostat for speed control. Although liquid rheostats have been applied for many years, there have been surprisingly few technical articles written describing the basic design and features of these devices. This paper has been written to acquaint the reader with the basic design of modern liquid rheostats and application data on various types of loads and control systems.

Industrial Power Systems

48-15—Suddenly Applied Loads Carried by a Variable Ratio Synchronous-Induction Frequency Changer; *A. G. Darling (M'44), G. A. Kaufman. 20 cents.* The induction machine of this frequency changer has demonstrated its ability to start and carry rotating machine induction loads requiring 140 per cent of the kilovolt amperes of the induction machine to start them without benefit of capacitive excitation. A-c amplidynes are used for automatic voltage regulation of the induction machine. D-c amplidynes are used for regulating the load through the frequency changer. So far as the authors are aware, this is the first commercial installation of this type to incorporate these features. The variable frequency ratio converter was selected for the Jones and Laughlin Steel Corporation, Pittsburgh Works, installation as it also offered the most economical method of interconnecting two systems of dissimilar frequency while controlling power flow to a constant amount.

48-16-ACO—Features of a New A-C Bus Design; *R. N. Wagner (A'44). 20 cents.* This paper describes the design of a new low reactance 3-phase a-c bus for loads of 2,000 to 5,000 amperes at voltages up to 600. The conductors consist of three specially shaped, electric conductor aluminum extrusions. They are arranged in a partial triangle and are spaced closely for low reactance. The conductor assembly is enclosed in a perforated or solid aluminum housing. The design features which make this "sector bus" practical are discussed in detail. Comparisons with conventional bus conductors are made on the basis of voltage drop, space required, weight, safety, and installed cost. Illustrations show actual installations in industrial plants.

48-65-ACO—The New D-C Sectionalization Application Standards; *M. W. Pennybacker (M'44), Donald J. Baker. 20 cents.* Recommendations for underground coal mine application of overcurrent protective devices are discussed in the light of the new d-c mine sectionalization application standards recently adopted by a committee sponsored by the United States bureau of Mines. The new standards were developed to provide a basis for greatly reducing the electrical hazards resulting from damaged mobile machine cables and from fallen trolley wires and feeders, the most common causes of mine fires. The paper illustrates the new sectionalization standards and discusses them, both from the standpoint of clarification and significance to the coal mining industry.

Instruments and Measurements

48-47—A Direct Reading D-C Bridge for Microwave Power Measurements; *Herbert J. Carlin (A'41), Judd Blass. 25 cents.* A description is given of a d-c bridge which operates in conjunction with a bolometer to measure microwave power magnitudes. The bridge utilizes the bolometer as one of its four arms and with radio-frequency power supplied is balanced manually. A d-c instrument then reads the radio-frequency power directly. A special L-pad attenuator is employed in a novel arrangement to give the resultant currents which are fed to the d-c meter. The latter has two coils and is connected as a summation instrument. The paper discusses the basic theory and design of the bridge and derives expressions to indicate the errors involved and their control.

48-48—A Broad-Band Signal Generator; *Thomas P. Hahn, John Ebert, W. A. Lynch. 20 cents.* Solutions of some of the problems arising in the development of a broadband signal generator are presented. Three internal cavity, reflex klystrons are used to cover the frequency range. Attenuator and wavemeter designs in coaxial radio-frequency cable are discussed, as well as attenuator calibration and accuracy of output power as read from a panel control. The method of pulsing the klystrons is described with emphasis on the problems involved in obtaining very short rise and decay times.

48-49—Microwave Frequency Measurements and Standards; *Benjamin F. Husten, Harold Lyons. 30 cents.* The method used at the National Bureau of Standards for the generation and utilization of standard frequencies in the microwave region is described. The method provides continuous frequency coverage from 300 megacycles per second up to and beyond 30,000 megacycles per second. All frequencies are derived from or measured in terms of the national primary standard by a process of frequency multiplication and harmonic generation. The standard is known at all times to within one part in 100 million. The output of highly constant precision oscillators is mixed with the multiplied standard frequency to provide an output with a frequency range of 10 per cent and centered at 10 megacycles per second. This output is passed through a frequency multiplier chain with outputs centered at 30, 90, 270, and 810 megacycles per second. Harmonics of these outputs, generated in silicon-crystal diodes, provide the microwave standard frequencies which have an accuracy of one part in 10 million or better. Facilities are also available for the generation of fixed frequencies at approximately 1 per cent intervals from 300 megacycles per second to 30,000 megacycles per second. These frequencies are derived from the primary standard and are known to within one part in 100 million. Possible sources of error in the calibration and use of typical microwave frequency meters and some means of reducing these errors are discussed. Some of the possibilities and future developments in the field of microwave frequency measurements and standards are discussed briefly including applications to related projects. Methods of extending the frequency range to the extreme high-frequency band also are discussed.

48-50—A Standard of Attentuation for Microwave Measurements; *R. E. Grantham, J. J. Freeman. 25 cents.* The use of the heterodyne, or intermediate-frequency substitution method, together with an accurately constructed intermediate frequency cutoff attentuator, as a standard of attenuation is described. Limitations and errors of the method are discussed. Measurements on several types of mode filters are given, together with measurements and discussion on the evaluation of the performance of the intermediate frequency attentuator.

48-67—A Bridge Method for Determining the Motional Characteristics of Permanent-Magnet Movable-Coil Instrument Mechanism; *Roswell W. Gilbert (A'36). 20 cents.* The instrument mechanism is expressed in terms of an equivalent electrical network, and the apparent electrical parameters determined by a-c bridge methods. The extracted parameters are: the apparent series resistance, the apparent damping resistance, the undamped period, and the periodicity at which the phase angle of reactance to the shunt resistance is −45 degrees. From these the periods and damping coefficients can be calculated. By including the d-c deflection sensitivity of the instrument the moment of inertia and the restoring torque gradient also can be calculated.

48-94—Relation Between Electrical and Mechanical Parameters of a Permanent-Magnet Movable-Coil Instrument Having a General Circuit; *W. N. Goodwin, Jr. (F'13). 30 cents.* This paper analyzes the relations between the mechanical parameters and the electrical parameters, as measured at the terminals, of a permanent-magnet movable-coil instrument, or other similar electromechanical device, the movable coil of which is free to oscillate, and the circuit of which may consist of any network of resistors which, in general, may be unknown. It is shown further that by measuring the apparent resistance, inductance, and capacitance at the terminals by a special bridge and oscillator, and the current per unit deflection, that the values of the undamped period, specific damping coefficient, moment of inertia, and spring stiffness can be computed regardless of the character of the instrument circuit resistor network, or whether it be known or unknown.

Insulated Conductors

48-7—Use of Reduced-Scale Models for the Solution of Cable Temperature Problems—II; *Andrew Gemant, Joseph Sticher (M'39). 25 cents.* The reduced scale cable equipment, as described in *AIEE Transactions (Jul '46, pp 475–82)* was used to give the following information on loading of eight 24-kv cables in a standard 3 by 4 duct bank.

1. Reproduction of complete cable temperature versus time curves in case of a week's load schedule as actually carried in the field.
2. Prediction of complete temperature versus time curves in case of a planned weekly load schedule.
3. Direct determination of maximum permissible loads without having recourse to "duct constants."
4. Determination of variation of cable temperatures with location of cable in duct bank.
5. Determination of temperatures of cables lying in dry ducts as compared with cables lying in wet ducts.
6. Analysis of complete cable temperature versus time curves, yielding the following data:

(*a*). Maximum temperatures.

(*b*). Relative probable life of cable insulation if a certain high load is applied any given number of times during the life of the cable.

(*c*). Maximum rate of temperature rise, that is, maximum rate of oil expansion.

Numerical results on the afore-listed items of information are presented in the form of graphs.

48-71—138,000-Volt Polyethylene-Sheathed Compression Cable—Pipe-Line Type; *J. E. McCormack (F'44), C. T. Hatcher (M'37), K. S. Wyatt (M'39), W. A. Del Mar (F'20), E. J. Merrell (A'41), J. H. Palmer (M'42), E. F. DeTurk (M'30). 40 cents.* In 1946 the Consolidated Edison Company of New York and the Long Island Lighting Company decided to install a 138-kv underground feeder to interconnect their two systems. An improved type of compression cable offering a number of advantages, which had been developed about that time by Phelps Dodge Copper Products Corporation, was selected. The system consists of three solid-type impregnated-paper-insulated cables, each having a bronze-reinforced extruded polyethylene sheath, installed in a steel pipe, in an oil medium maintained at 200 pounds per square inch by terminal pumps. The system thus combines the pressure characteristics of previous oil-pressure systems with the advantages of the protective sheath of the European gas-pressure systems with the difference that the lead sheath of the latter has been replaced by a nonmetallic sheath. The cable is automatically self-compensating because it is oval-shaped and changes its ovality in response to changes of internal pressure during load cycles. The cable was installed in lengths up to 2,300 feet, and both normal and semistop joints were used, installed in concrete manholes. The pipe was chill-ring welded and coated inside with a lacquer and outside with an extruded asphaltic composition. It was tested at 500 pounds per square inch before cable was installed. Successive sections of the paper deal with history and general principles, electrical characteristics, accessories, and field work on the first installation of this kind.

48-72—115-Kv High-Pressure Oil-Filled Pipe Cable Installation at New Orleans, La.; *W. R. Bullard (M'26), A. D. Pettee (F'46), G. L. Rhodes (A'36). 40 cents.* The first major high-voltage pipe-type installation in the United States to be installed without any stop joints and the first in which the cable was shipped without the conventional temporary lead sheath was placed in service in June 1947, by New Orleans Public Service, Inc. This installation incorporates a number of novel design features of unusual interest. The paper describes these features and reports the results of tests and studies carried out in connection with this installation.

48-73—Thermal Characteristics of a 120-Kv High-Pressure Gas-Filled Cable Installation; *W. D. Sanderson (M'41), Joseph Sticher (M'39), M. H. McGrath (A'26). 40 cents.* A summary of pertinent data on the thermal characteristics of 120-kv high-pressure pipe-type cable is presented with the idea that these results may be of aid in the design of pipe-type cable systems. The Detroit Edison Company has been operating an experimental installation in co-operation with the General Cable Corporation, along with a commercial installation on the Detroit Edison system since 1941. Data obtained from these two installations, as well as from laboratory tests, have provided an excellent opportunity to check the thermal constants normally used in current rating calculations. The components of the thermal path are considered, individually. The paper includes a comparison between gas and oil as the pressure medium, and determinations of extra a-c losses, soil resistivity, and temperature distribution prevailing in such a cable installation during various loading schedules.

Land Transportation

48-36—Comparative Operating Results of Steam, Diesel-Electric, and Electric Motive Power on the Great Northern Electrification; *J. F. N. Gaynor. 20 cents.* The paper describes electrical operations from early 3-phase tunnel-type locomotives to the modern motor-generator locomotive. Performance comparisons and costs are given for steam, electric, and Diesel-electric motive power on same profiles. Methods of testing the various types of motive power for running adhesion limits, rail horsepower, and tonnage ratings necessary for satisfactory operation of all three types in same train are discussed as well as heavy tonnage operating methods used to haul any desired tonnage on maximum grades, up to limit of passing tracks' capacity, by means of proper location of swing helper locomotives in a train. The superiority of motor generator locomotives for heavy traction service, and the relationship between initial investment, along with power costs, maximum demand rates, and clocking are shown with their probable effect on future electrifications. Suggestions of motive power standardization and a standard power system as affecting electrification are given.

48-37—Railroad Electrification Energy Conversion and Transmission Costs; *R. L. Kimball (A'36), J. G. Holm (M'29). 30 cents.* The paper deals with costs and design of conversion and transmission requirements for railroad electrification from a point of power purchase to the point of delivery to electric locomotives. A 330-mile railroad is discussed. Single-phase 25-cycle electrification, with 24 kv on the trolley and 72-kv feeder voltage, and a 6,000-volt d-c electrification are compared. Frequency changers, mercury rectifiers, wood pole supporting structures are employed. On the basis of design adopted the results show that it is possible to obtain an installation at a favorable cost, using either alternating or direct current. The economy of electrification depends on the traffic density. Considerable savings are obtained by having a high power factor at the locomotive and by making use of power interchange between main substations of an a-c system. Should the prices for d-c equipment go down as the apparatus is developed further, the d-c versus a-c comparison will become more favorable to direct current.

48-38—Are the Overhead Distribution Costs Retarding Railroad Electrification?; *L. W. Birch (M'29). 40 cents.* Electrification of steam railroads in the United States and Canada in the past decade has not kept pace with previous periods. But, during the past ten years electrification of heavy mine haulage, industrial tracks, certain terminal and suburban centers, and foreign railroads, has continued. Could it be that economics do not favor the electrification of the large steam railroads in this country at the present time? If so, does the cost of the overhead distribution system contribute to the slowing down of electrification? This paper discusses recent developments in overhead design that, it is believed, will tend to reduce distribution costs. The paper also discusses possible means of reducing construction costs, particularly by suggesting certain substitutes for the high-cost work train. Certain changes in the general dimensional limitations to overhead clearances for the distribution system are proposed and the economic advantages of these changes are discussed.

48-39—Shunt Capacitor Installation for Single-Phase Railway Service; *H. F. Brown (F'47), R. L. Witzke (M'45). 30 cents.* A 10,000-kva bank of shunt capacitors recently placed in service on the 22-kv electric traction system of the New York, New Haven, and Hartford Railroad, is the first installation of this kind to be made on a 25-cycle single-phase system. Made up of 25,400 kva of 60-cycle 15-kva units, it is also one of the larger capacitor banks in operation. The installation is tuned by means of series reactors to control both the third and fifth harmonic voltages on the traction system. The units are switched automatically in steps of approximately 2,500 kva each. This reactive supply has increased the traction system voltage by as much as 20 per cent, and has released 6,000 kw in generating capacity during peak load conditions. In addition, it will save an estimated $20,000 a year in cost of energy losses by decreasing the hours of operation of several large frequency changers, previously operated much of the time as synchronous condensers for voltage control. This paper reviews the conditions giving rise to the need for additional reactive capacity, compares the relative costs of synchronous condensers and shunt capacitors for 25-cycle single-phase service, and discusses the problems incident to the installation of capacitors on a railway system. The general characteristics of the capacitor station are given in some detail. Six months operating experience, and test results are reported.

48-51-ACO—A-C Air Conditioning for Railroad Passenger Cars; *H. H. Hanft. 20 cents.* A-c passenger-car air conditioning equipments have been developed to reduce equipment weights and to eliminate many items liable to equipment failure. Such a-c cooling systems are powered by steam turbine generators, or by Diesel or gas engine generators. Storage batteries are reduced to nominal size and weight and operate on a relatively light duty cycle. Maintenance needs and liability of equipment failure are reduced by eliminating many maintenance items entirely, and by substituting squirrel-cage induction motors for d-c machines with commutators and brushes.

48-52—Speed-Responsive Devices on Diesel-Electric Locomotives; *A. V. Johansson (A'47). 20 cents.* Modern Diesel-electric locomotives usually employ two motor combinations and one or more steps of field shunting in each combination. A method of selecting proper motor connections automatically on a basis of train speed is described.

48-53—A Unique Application of the Wheatstone Bridge to High-Speed Train Braking; *C. M. Hines (M'45). 20 cents.* This paper describes a method for indicating to the locomotive engineman the condition of the circuits controlling the electropneumatic brakes which are now in widespread use on high speed passenger trains. The apparatus consists of a Wheatstone bridge so arranged as to insure the operation of the bridge itself as well as to indicate the condition of the electropneumatic brake circuits. Calibrated dials indicate the number of vehicles in the train. This equipment is proving to be a useful tool in making terminal tests, and in assisting in determining the location of any change of resistance of the train line wire circuits which may occur. It also provides a convenient means for indicating to the engineman while en route any change which may occur in the train line circuits. All parts of the equipment are designed to provide the ruggedness essential for long life on locomotives.

48-54—Electric Locomotives With Identical Basic Components; *W. A. Brecht (M'39), Charles Kerr, Jr. 20 cents.* A complete line of electric locomotives is described ranging in capacity from 1,875 to 7,500 continuous rail horsepower where all locomotives utilize identical 4-wheel trucks. The 1,875-horsepower unit employs two trucks (4 axles) and the 7,500-horsepower unit, 8 trucks (16 axles). For a given a-c or d-c trolley supply, identical motors would be used, the proper gearing being selected for passenger, freight, or switching service. Most control and auxiliary equipment will be identical throughout the series, the quantity varying according to size. This method of construction would permit a degree of standardization never obtained previously with electric locomotives. Thus, first cost can be reduced. Rigid standardization of parts, especially those subject to wear, will result in low maintenance expense. In addition, the entire series provides other attractive features, including good tracking qualities at all speeds, light axle loads (45,000 pounds), sustained power over the entire locomotive speed range, all weight on drivers, high starting and running tractive effort, and conservative adhesion values. The ideas discussed in this paper constitute a new conception of electric locomotive design.

48-62-ACO—Electrically Propelled Vehicles Most Economical in City Transit; *G. M. Woods (M'43). 25 cents.* Modern streetcars and trolley coaches are an economical means of furnishing city transit service over a wide range of passenger traffic densities. In many other respects, the electrically propelled vehicles exceed competing forms of urban transportation. In spite of these facts, the number of gasoline and Diesel buses has increased rapidly with a corresponding decrease in number of streetcars. As a result, the total electric energy used by urban transportation has decreased materially. The number of trolley coaches has increased rapidly in the last ten years and holds promise of further extensions. The considerations affecting the selection of transit vehicles including an economic analysis of a hypothetical example are included in the paper.

48-63—Trolley Coach Distribution System; *G. R. McDonald (A'21). 35 cents.* This paper describes a simple, quick method for the layout of trolley coach distribution systems. Calculations are reduced to a minimum. The method insures consistent results and makes it easy to check variables such as substation locations and feeder circuit arrangements to arrive at an economical layout. In addition to furnishing information on feeder copper, the method takes care of fault isolation and adequate operating voltage. A number of the problems commonly encountered with this type of d-c distribution system are discussed.

48-64—Three-Compartment Articulated Cars for Test on Rapid Transit Division, Chicago Transit Authority; *H. A. Otis. 20 cents.* Two rapid transit articulated cars have been bought to run on the elevated and through the subway to test their adequacy for operation in Chicago. Each 3-body car weighs 93,000 pounds, seats 96 passengers, and has a maximum capacity of 250 passengers. Aluminum has been used to keep the weight within the capacity of standard Presidents' Conference Committee streetcar equipment. Many standard parts have been used and others have been changed slightly. The trucks have been adapted for increased weight and the control for multiple unit operation. Special body construction provides wide seats. A very complete and entirely automatic heating and ventilating system provides for passenger comfort, winter and summer.

48-97—Power Costs and the Contribution of Existing Transmission Networks Towards Cost Reduction of Power for Electrification of Main Line Railroads With Moderate Traffic; *Llewellyn Evans (F'41). 20 cents.* This paper is one of a symposium on the subject of electrification of main line railroads having medium traffic and depends on paper 48-37 by R. L. Kimball and J. G. Holm on the subject of

"Energy Conversion and Transmission Costs" for a full description of the railroad and the electric equipment. The symposium gathers the facts and costs on the premise that main line railroad electrification can be extended profitably to include medium traffic railroads and should not be confined necessarily to the field of heavy traffic and heavy grades. Power costs are the theme of this paper which sets up and distributes the estimated electricity requirements for each station and computes the bills for an a-c 25-cycle scheme with 1940 traffic as 100 per cent and present traffic as 157 per cent of normal, and like estimates for a d-c system.

Metallic Rectifiers

48-66—Twenty-five Years of Copper-Copper Oxide Rectifiers; *L. O. Grondahl (F'47). 30 cents.* The discovery of the rectifying characteristics of a copper-cuprous oxide junction was made in the fall of 1920. There followed from 1921 on an intensive development program resulting in the first practical use of the rectifier in 1924 in railway train control. Commercial use became considerable in 1926, and has been growing ever since that time. The paper gives a discussion of the development of the rectifier element, a description of the application to a wide range of units requiring capacities from microwatts to kilowatts, and large ranges in currents and voltage. Characteristics and their dependence on presence of impurities and on manufacturing conditions are described. A brief reference is made to theory. Methods of testing, and large scale manufacturing processes are outlined.

Mining and Metal Industry

48-14—X-Ray Thickness Gauge for Cold Rolled Strip Steel; *Walter N. Lundahl. 30 cents.* An X-ray gauge for measuring the thickness of cold rolled strip steel as it comes from a mill or before it is cut in a flying shear has been developed which permits closer control of material thickness in the modern high speed mill. After briefly outlining the basic theory and the principles involved in X-ray thickness gauging, the paper describes the electrical and mechanical details of the new cold mill gauge.

48-22—Electric Equipment for Cold Strip Reduction Mills; *W. E. Miller (M'45). 25 cents.* The cold rolling of steel strip is a process that has been practiced actively for more than a half century. Fifteen years ago the fastest mills had delivery speeds of 800 feet per minute. Today some tandem mills are capable of delivery speeds in excess of 5,000 feet per minute. A modern high-speed tin plate mill may have a total connected horsepower exceeding 16,000. Yet, such mills must roll strip as thin as eight thousandths of an inch. High rolling speeds, large amounts of power, thinness of strip, and rigid gauge tolerances have brought about the development of an entirely new control system. Rolling problems, schedules, and power requirements for strip reduction are considered in selecting ratings of main motors, generators, and the control system for a typical 5-stand tin plate mill. Schematic diagrams of circuit elements are included. Stabilizing problems are considered and a frequency response curve shown for a voltage regulator with IR compensation.

48-80-ACO—Electrical Control Problems in Coal Mines; *C. O. Wood (M'46). 20 cents.* Modern day underground mining machinery must be extremely rugged to withstand the service demanded of it, and at the same time must be compact to permit efficient use in restricted space. Both of these conditions present difficulties in designing electric control equipment, which is complicated further by poor power distribution with greatly varying voltage, and the corrosive effect of acid-laden mine air on metal parts. This latter is emphasized more sharply on permissible equipment where corrosion is quite severe in confined compartments as a result of nitrogen and oxygen compounds generated by arcs. Poor maintenance and cramped wiring inside compartments are further problems which influence control design.

48-100—An X-Ray Thickness Gauge for Hot-Strip Rolling Mills; *C. W. Clapp, R. V. Pohl. 25 cents.* A noncontacting gauge is described for use in measuring continuously the thickness of rolled steel in a hot-strip rolling mill. This thickness is measured by the absorption of an X-ray beam of known intensity as it passes through the strip. The difficult problem of stabilizing the X-ray beam has been solved and the indication of steel thickness is given directly in terms of two standard steel wedges. Operating experience obtained in an installation at the Irwin Works of the Carnegie-Illinois Steel Corporation is discussed.

Power Generation

48-2—Generator Stability at Low Excitation; *E. L. Michelson (M'44), L. F. Lischer (A'38). 30 cents.* The addition of static capacitors for power factor correction on the 4-kv distribution circuits of the Chicago system has resulted in the operation of generators at power factors close to unity during light load periods. This introduces a problem of generator stability at low levels of excitation. This paper presents the methods and results of a study on the operation of the generators on the Chicago system during these light load periods, and shows to what extent capacitors may be added to the system without resorting to capacitor switching. The paper shows that loss of generator field presents the most serious problem in the operation of generators during such light load periods.

48-81—Underexcited Operation of Turbine Generators; *C. G. Adams (A'41), J. B. McClure (A'29). 20 cents.* This paper reviews underexcited operation of turbine generators. Margins in pullout power for hand control of generator excitation are shown for various system and machine conditions. Voltage regulator operation in the underexcited region is discussed. Some modern voltage regulators incorporate means for limiting the minimum generator field current as a function of kilowatt load to predetermined values. An area on the generator reactive kilovolt amperes versus kilowatt plot is suggested for the setting of this type of limit. Simple methods for calculating generator loading limits as determined by rated generator field and armature currents and by system stability requirements are shown.

48-82—Rototrol Excitation Systems; *J. E. Barkle (A'40), C. E. Valentine (M'41). 20 cents.* The development of the Rototrol amplifier as a portion of the excitation system for a-c synchronous machines has brought about changes in all parts of the excitation system. The paper discusses various methods of using the Rototrol as a pilot exciter in the excitation systems for turbine generators, hydroelectric generators, and synchronous condensers. The voltage regulator used with the Rototrol is a static device of either the impedance network type or the electronic type. Adequate excitation to maintain stability for any load condition is assured by a minimum excitation limit which responds to kilowatt load. Other types of limits also are discussed. Each of these devices is described and methods of co-ordinating their use in excitation systems given.

48-83—Main Exciter Rototrol Excitation for Turbine Generators; *C. Lynn (M'43), C. E. Valentine (M'41). 20 cents.* The use of a main exciter, built in the form of a Rototrol for a turbine generator and direct-connected to the generator shaft, provides excitation, stability, and voltage regulation for the a-c generator with only one moving part, the rotor of the exciter. The elimination of the pilot exciter and contact making regulator simplifies the excitation system and improves the operation. To reduce the control energy required from the static voltage regulating network for such a large Rototrol, it is made in the form of a 2-stage amplifier. Factory tests simulating operating conditions of the Rototrol excitation system are compared with similar tests of a conventional main exciter, pilot exciter, and contact making voltage regulator.

48-89-ACO—Hydraulic Turbine Governor Specification; *E. B. Strowger, C. L. Avery. 20 cents.* The Joint AIEE-American

Society of Mechanical Engineers Committee on a Recommended Specification Covering the Speed Governing of Hydraulic Turbine-Generators now is presenting a set of specifications for one year's trial use prior to its proposed adoption by the parent associations. This paper attempts to explain the various provisions of the specifications and the reasons underlying their adoption and discusses certain points of deviation between provisions adopted and those contained in AIEE Specification 600 covering governors for steam turbogenerators.

48-90—Precise Turbine Governor; *H. E. Warren (A'02). 20 cents.* Hydraulic governors for the control of turbines have been improved in the recent past principally by the addition of supplementary precision controllers. The author describes a form of governor in which precision is made inherent by eliminating the dash-pot and applying instead a direct frequency comparison device. The latter includes simple means for obtaining speed droop and tie-line or other bias, and for improved manual control of the governor from the switchboard. Practically all governors in current use measure speed or frequency by balancing centrifugal force against spring force. The absolute precision obtainable is generally poorer than 1/100 of 1 per cent. In this new governor a dependable precision at least ten times greater is feasible and the objectionable dead bands common to existing governors can be eliminated without supplementary apparatus.

Protective Devices

48-78—Survey of Lightning Protective Equipment for Rotating A-C Machines; *Lightning Protective Devices Subcommittee. 20 cents.* As present practices with respect to the protection of rotating a-c machines against the effects of lightning vary somewhat, this survey was initiated to compile information covering these applications. The types of equipment are listed, the basic reasons for installing or not installing such equipment are included, and the possibility of applying such equipment in the future is noted. Tests are now in progress in some companies to determine the value and efficiency of such installations. Unfortunately, these tests have not progressed sufficiently to provide accurate conclusions. In general, past experience and exposure conditions are the general criteria for installing such protection, and present-day practice seems to favor more of this protection, particularly using arresters and wave-sloping capacitors in combination.

48-79—Expulsion-Type Lightning Arresters—Impulse Sparkover Volt-Time Characteristics; *AIEE Lightning Protective Devices Subcommittee. 20 cents.* This report presents the impulse sparkover data on expulsion arresters of the distribution type as they are available currently. Average curves are based on the average data from the seven manufacturers. Maximum and minimum values which include the characteristics for all manufacturers are tabulated.

Recommended Specifications

48-4-ACO—Recommended Specifications for Speed-Governing of Steam Turbines Intended to Drive Electric Generators Rated 500 Kw and Up; *Joint AIEE-ASME Committee on a Recommended Specification for Prime Mover Speed Governing. 35 cents.* The specifications recommend minimum functional and performance characteristics relating to the speed-governing of steam turbines intended to drive electric generators, operating isolated or in parallel with other generators, at constant speed. The specifications are limited in scope to the following types of steam turbines rated 500 kw and up:

(*a*). Straight condensing, straight noncondensing, and nonautomatic extraction turbines without initial and/or exhaust pressure control.

(*b*). Straight condensing, straight noncondensing, and nonautomatic extraction turbines with initial and/or exhaust steam pressure control.

(*c*). Automatic extraction and mixed-pressure turbines.

The equipment and performance specifications are arranged in three parts applicable to the foregoing grouping for the convenience of the user. Although primary interest is in speed-governing, material on steam pressure control has been included to the extent that such control influences the speed governing of the steam turbine. These specifications are intended to replace the recommended specification currently available as AIEE publication 600 (July 1944), and are presented for general and specific comments which cordially are invited.

48-5-ACO—Recommended Specification for Speed Governing of Hydraulic Turbines Intended to Drive Electric Generators; *Joint AIEE-ASME Committee on a Recommended Specification for Prime Mover Speed Governing. 35 cents.* The specification recommends minimum functional and performance characteristics relating to the speed-governing of hydraulic turbines intended to drive electric generators at constant speed, and is applicable to the speed-governing of the following types of hydraulic turbines:

(*a*). Impulse turbine
(*b*). Francis turbine
(*c*). Fixed blade propellor turbine
(*d*). Adjustable blade propellor turbine

The committee has endeavored to include only items of general application and has guarded against specific developments which might not be accepted generally as standard. The specification for the present is not complete with reference to the speed-governing of adjustable blade propellor turbines, pending completion of necessary studies currently underway. Wherever possible, the committee has endeavored to co-ordinate this specification with the ones for the speed-governing of steam turbines. The specification is presented for general and specific comments which cordially are invited.

Relays

48-6—Bibliography of Relay Literature, 1944-46; *Interim Report by the Project Committee on Relay Bibliography of the Relay Committee (Power Group). 25 cents.* This report lists all important articles on the subject of protective relaying and associated equipment from 1944 to 1946 inclusive published in the AIEE *TRANSACTIONS* and *ELECTRICAL ENGINEERING*, as well as most of the chief technical publications in the world. Previously, this report has been available only to the members of the relay committee in annual reports. The thought of the relay committee in publishing this bibliography at regular intervals is that it is desirable to place this complete bibliography in the hands of those interested in the subject before the information becomes obsolete. This report will supplement the papers, "Bibliography of Relay Literature, 1940-1943" published Oct. 1944, and "Bibliography of Relay Literature, 1927 to 1939" published in July 1941 by the Institute.

48-12—Relaying Difficulties Disclosed by Staged Fault Tests; *W. A. Morgan (M'42), Byron Evans (M'47). 30 cents.* The value of staged fault tests prior to the placing into service of special long-line-type directional-distance-carrier relaying and 20-cycle reclosing circuit breaker equipment is demonstrated. High-frequency line-charging currents which occur at the instant of energizing a long high-voltage transmission line cause instantaneous-ground carrier relays to operate incorrectly and a filter circuit must be developed to prevent undesirable line tripping. The need for backup protection of the second element of the long-line-type directional-distance relays when the third element has its direction reversed for use with carrier is shown. The tests show that low ohmic interrupting resistors in some modern circuit breakers allow the fault to persist for two or three cycles after the main contacts open, which raises the question of whether the rated interrupting time is obtained in actual practice.

48-13—Service Restoration with Automatic Airbreak Switches; *Kenneth N. Reardon (M'45). 25 cents.* Automatic pole-top air switches have been used for more than 20 years by the West Penn Power Company for fault isolation and service restoration on an extensive 25,000-volt distribution system. Nearly 100 automatic air switches are now in service; they have proved to be a reliable and economical means of reducing the duration of power interruptions caused by temporary and permanent faults. This paper is an exposition of five types of automatic air-switch applications on West Penn Power Company lines. The transfer and sectionalizing types are analyzed in detail. Simplified control diagrams are given and their scheme of operation is disclosed clearly. The paper contains illustrations of sectionalizing stations located singly—and also in series—in lines having one, two, and three sources of power supply. Service restoration time schedules are presented graphically for temporary and permanent faults at various points on the lines.

Rotating Machinery

48-27—Steady-State Equivalent Circuits of Synchronous and Induction Machines; *Gabriel Kron (M'45). 30 cents.* Equivalent circuits are developed for the various types of salient-pole synchronous and asymmetrical induction machines, expressed along the physical direct and quadrature axes. The torques again are found by direct measurement of power. The networks of the various types of machines, operating also at other than fundamental frequencies, are found as special cases of that of the "primitive" machine. All equivalent circuits along the physical axes are derivable from those along the hypothetical symmetrical-component axes by a real transformation. Although the latter circuits already have been published previously, they are reproduced for comparison with the new networks and for a unified tensorial treatment of rotating machines and their equivalent circuits.

48-28—Induction Machinery Theory Relating to a Special Feed-back Generator; *H. Vickers (F'34). 20 cents.* A study is made of an induction-type generator, in which the generated voltage in the signal phase is made proportional to the speed, and in which the phase angle between reference and signal voltages does not change over the speed range by more than a small fraction of a degree. The conditions to be satisfied to obtain these results are determined. The method of attack is applicable to the single-phase induction motor.

48-29—The Single-Phase Synchronous Machine; *Ira A. Terry (F'37), B. L. Robertson (F'43). 30 cents.* This paper describes the theory of the performance of single-phase synchronous machines and presents test results in verification of the theory. The material in the paper is based upon work done by the authors quite a number of years ago, and is presented as an extension of the use of the 2-reaction theory of analysis of synchronous-machine performance. Types of single-phase power and single-phase synchronous machines in commercial use are considered first. Following this there is given a theoretical analysis of single-phase synchronous machines. In this analysis, steady-state conditions are considered first, based on the classical assumption of no saturation and no stator hysteresis or eddy-current losses, treating the machine generally as a 3-phase machine with direct and quadrature axes of symmetry and with one phase winding left idle. Considerations also are given to the effects of sudden changes in loading, sudden changes in circuit, starting performance, and load losses.

48-30—Performance of the Single-Phase Synchronous Machine; *B. L. Robertson (F'43), T. A. Rogers (M'37). 20 cents.* The trigonometric form for the steady-state terminal voltage of the single-phase synchronous machine is expressed in terms of complex algebra and further interpreted by the vector diagram. Comparison of test data with calculated values obtained from the diagram, and for complete load runs under both generator and motor action, show a very close agreement between actual performance and developed theory. The order and magnitude of prominent harmonics in voltage and current are given for several wave shapes, and the conclusion reached that the harmonic content of these quantities may be neglected in the steady-state analysis of this type of machine.

48-31—A Study of the 3-Phase Commutator Armature With Six Adjustable Brushes; *Paul W. Franklin (A'39). 30 cents.* This paper attempts a detailed study of the characteristics of a 3-phase commutator armature with six adjustable brushes per pole pair. As the brushes are being shifted, the effective number of turns per phase, phase resistance, phase leakage reactance, and flux shape, change considerably. These values are being derived as a function of the brush spacing angle and, with the help of the Goerges diagram, the resulting flux shapes are being determined. Furthermore, the change of leakage reactance with varying armature speed is being discussed. The principles of the derivations are general and may be applied to any similar problems.

Servomechanisms

48-84—The Effect of Coulomb Friction on the Performance of Servomechanisms; *G. D. McCann (M'44), F. C. Lindvall (F'43), C. H. Wilts. 30 cents.* The effect of coulomb friction on the performance of both position and speed-regulating servomechanisms has been studied in considerable detail by means of the electric analog computer. The analysis shows the effect of varying amounts of coulomb friction in addition to viscous damping on the design of basic servomechanisms and on over-all performance, including speed of response, system damping, and steady-state error. Three basic types of systems were analyzed, one of these being a position follow-up servo with coulomb friction in the position of the system containing the follow-up motion. Another is a speed-governed system described by a cubic equation with coulomb friction in the governor. The third is an autopilot with coulomb friction in the rudder control system.

48-85—Graphical Analysis of Control Systems; *W. R. Evans (A'42). 35 cents.* The purpose of this paper is to demonstrate some graphical methods for finding the transient response of a control system. The key fact, pointed out by Doctor Profos of Switzerland, is that a vector plot of the error/output ratio as a function of both damping and frequency is a grid of curvilinear squares. Thus the Nyquist plot for frequency alone can serve as a base line for which a "flux plot" can be sketched to the -1 point to determine the principal complex roots of the system. For systems with known analytical form, a graphical method for calculating the complex plot is shown. In any case, the amplitude of a transient term is determined once its root is known by use of a theorem of operational calculus. The possibilities for further development of the method are believed to be very great.

Switchgear

48-23—A Study of A-C Arc Behavior Near Current Zero by Means of Mathematical Models; *T. E. Browne, Jr. (M'45). 40 cents.* The differential equations of two idealized models of the arc column proposed by previous writers have been combined into a composite model whose behavior approximates that of actual a-c power arcs in circuit breakers and fuses near a critical current zero for arc extinction. An extensive series of curves are presented showing, for this model, the variation with time just before and after current zero of arc resistance, arc current, arc power, and dielectric strength of the arc space under certain simplifying assumptions for three different forms of circuit recovery voltage. These quantities are expressed in terms of prior arc current and voltage and of a characteristic "time constant" which depends upon the physical conditions imposed upon the arc. The model curves are compared with oscillographic measurements. The usefulness of such models in aiding the understanding of arc behavior in circuit interrupters and in correlating and making extrapolations from interrupting data is pointed out.

48-24—A Compressed Air Circuit Breaker for 23-Kv Arc Furnace Duty; *H. M. Wilcox (M'27), B. P. Baker (M'41). 20 cents.* The latest addition to the line of electric equipment now available to the users of steel-making electric arc furnaces is the compressed air circuit breaker. This was designed for highly repetitive service consisting of interrupting transformer magnetizing current, arc furnace load current, and secondary transformer faults of 300 amperes or less. The circuit breaker is built on an open steel frame with all moving parts mounted on and interconnected through sealed ball bearings. A surge suppressor consisting of a nonlinear resistance is provided to reduce the switching overvoltages to less than half of their normal value. The almost complete elimination of inflammable material makes this circuit breaker safe for use in the transformer vault or similar room. All insulating parts are dimensioned liberally for electrical integrity and made from various grades of Micarta to give strong, rigid, shock-proof structure. Uninterrupted satisfactory performance was obtained on a life test, consisting of more than 100,000 operations, 30,000 of which were with power, on currents ranging from 0.3 to 3,500 amperes at voltages from 23 to 36 kv. These tests were made on a circuit which was a laboratory model of an industrial circuit and the circuit breaker operated at air pressure from 100 to 60 pounds per square inch, which demonstrates that, in an emergency, the circuit breaker can be operated on a shop air line, and still meet the steel industry requirements where reliability, continuity of service, safety, and absence of damaging overvoltages are demanded.

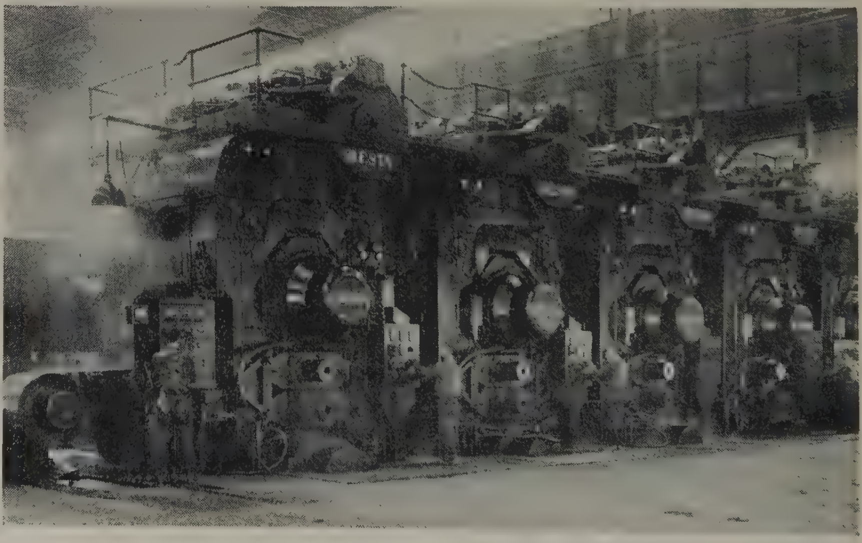
48-26—Arcing Fault Currents in Low-Voltage A-C Circuits; *C. F. Wagner (F '40), L. L. Fountain (M '45). 25 cents.* Test results are given for short circuits on 500-, 250-, and 125-volt circuits on which the short circuits have initiated in a conventional switchgear cubicle by means of copper wires of different sizes and by means of metallic bars resting across the bus bars. The magnitude of the currents are compared with those obtained under "bolted-fault" conditions. Arcing faults are unstable and will extinguish themselves within two cycles on a 250-volt or 125-volt circuit. About half the line-to-line arcing faults on the 500-volt circuit were unstable. For the 3-phase 500-volt tests the current "hung on." On a 500-volt circuit, the average first half cycle rms current is less than the 0.9 of the symmetrical bolted-fault current for currents in excess of 40,000 amperes symmetrical and about equal for currents below 40,000 amperes symmetrical. These factors compare with the 1.25 factor recommended at present by the AIEE for calculation of "bolted-fault" short circuits.

48-40—A 230-Kv 3-Cycle Oil Circuit Breaker for Extra-Heavy Arc Rupturing Duty; *W. M. Leeds (M '38), G. B. Cushing (A '40). 25 cents.* As the ultimate generating capacity of Grand Coulee Dam is approached, designers of high-voltage circuit-interrupting devices are challenged to produce circuit breakers capable of interrupting faults far in excess of the present maximum standard rating of 3,500,000 kva. An oil circuit breaker designed for extra-heavy arc rupturing duty is described in this paper. Results of varification tests made in the laboratory are compared with those obtained on subsequent field tests at Grand Coulee Dam. The close correlation of circuit breaker performance in the field and laboratory confirms the accuracy of the laboratory method of testing. With successful correlation up to 7,500,000 kva and laboratory tests simulating still higher rupturing duty, there is now a sound basis for design of oil circuit breakers with a rated interrupting capacity up to 10,000,000 kva.

48-41—Unusual Performance of Standard 230-Kv Impulse and Tank-Type Oil Circuit Breakers on Field Tests; *E. B. Rietz (A '42). 20 cents.* The requirements of the United States Bureau of Reclamation for 230-kv circuit breakers at Grand Coulee Dam which far would exceed present-day standard circuit breaker ratings, required field tests to check the performance of standard circuit breakers to predict the required designs for higher ratings. Standard 3,500 megavolt-ampere low oil content impulse and tank-type oil circuit breakers were tested on the maximum capacity available of over 7,000 megavolt-amperes. Unusually satisfactory performance was observed under all test conditions indicating that standard circuit breakers of these types incorporating modern methods of arc interruption, will require but little change to adapt them to the Grand Coulee Dam requirements for ratings of 10,000 megavolt-amperes.

48-42—Field Tests for Development of 10,000,000-Kva 230-Kv Oil Circuit Breakers for Grand Coulee Power Plant; *C. L. Killgore (M '47), W. H. Claget (M '46). 40 cents.* This paper discusses the recent field tests made at Grand Coulee power plant on Westinghouse and General Electric oil circuit breakers to determine the maximum interrupting capacity breakers which can be developed for 230-kv systems and the characteristics toward restrikes and possible overvoltages during interruption of line-charging current. More than seven million kilovolt-amperes at 230-kv was interrupted during these tests which exceeds any similar tests made previously. Reclosing tests with speeds of 12 cycles were made on both solid and arcing faults. Interruptions of line charging current up to 382 miles of 230-kv line were made. As the result of these field tests it was concluded that 10,000,000-kva interrupting capacity 230-kv circuit-breakers could be developed at this time and that no derating factor would be required for one 20-cycle reclosure.

48-43—Performance Tests of the AEG (German) Free-Jet Air-Blast 220-Kv 2,500-Megavolt Ampere Reclosing Circuit Breaker; *A. Dovjikov (M '41), C. C. Diemond (M '45). 30 cents.* The tests of the AEG (German) 230-kv single-interrupting-contact air-blast reclosing circuit breaker were made on the system of the Bonneville Power Administration in the presence of many representatives of American manufacturing and operating engineers. Fault currents were interrupted successfully up to approximately rated capacity (with and without reclosing) in about six cycles. Line charging current interruptions although successful were accompanied, as could be seen from oscillograms, by many restrikes. Although inferior in performance to the best oil and oil-poor circuit breaker of American manufacture, the absence of oil, the ease of visual inspection of contacts in free air, and the ease of their maintenance are very attractive features; and it is hoped that the tests would stimulate the American development of improved version of the German prototype.



View of typical 5-stand tandem cold-tin-plate mill which will be discussed at the AIEE 1948 winter general meeting in Pittsburgh, Pa.

Telemetering

48-44—New Devices Derived from a Torque Balance Telemeter; *W. H. Burnham. 20 cents.* This paper describes two pieces of auxiliary telemetering equipment which expands the field of application for the torque balance telemeter, as well as providing desirable functions in other telemetering systems. Use of the torque balance load injector as a phantom telemeter transmitter or a signaling device between generating stations and the dispatcher's office is explained. Applications of the torque balance converter, such as integrating a telemetered reading of tie-line power flow and providing a way to telemeter a totalized reading, are discussed.

48-45-ACO—Modern Telemetering System—Providing Kilowatt Indication, Recording, Integration, and Demand; *R. G. Meyerand (M '37). 20 cents.* The paper discusses the requirements for efficient load dispatching in the Union Electric System. The need for improvement in handling load assignments to the various plants required the planning and installation of a comprehensive telemetering system. The system selected uses audio tones on both telephone lines and carrier channels to transmit the telemetering impulses. Only kilowatt values are telemetered in the initial installation, but the existing facilities can be enlarged to include telemetering of vars and load control. Impulse duration-type telemetering instruments are used. Kilowatt indication, recording, integration, and integrated demand are provided. This is believed to be the first system to use integration for all telemetered circuits. The conclusion discusses the operating experience and the use made of the information obtainable. More economic distribution of loads between steam and hydroelectric plants is of prime importance, but many other uses have been made of the telemetering system.

48-46—A Faster Telemeter for Carrier-Current Channels; *E. E. Lynch (M '35), H. C. Thomas (M '47), G. S. Lunge (A '23). 20 cents.* A fast responding telemetering system, ideally suitable for use over the conventional types of carrier-current channels, is described together with operating data and application notes. The new system is of the frequency type, and employs as the translating means an electric signal whose frequency varies over the range from 6 to 27 cycles per second in direct proportion to the measured quantity. A continuous output signal is provided which will operate directly the usual types of indicating and recording instruments. The system has inherently a high degree of accuracy and stability, and the design is such as to provide long life with minimum maintenance. A-c watts, vars, volts, and amperes may be telemetered directly. Auxiliary equipment is available to permit telemetering of practically any other electric or nonelectric quantity.

Transformer

48-18—Influence of the Core Form Upon the Iron Losses of Transformers; *G. M. Stein (M '38). 40 cents.* Formulas for the iron loss calculation of single- and 3-phase punching cores are developed from the actual magnetic field distribution in the core, and from the properties of its material. This field analysis is confined to the potential chart of a single corner by applying a correction derived from more elaborate models. The result appears as a fictitious weight, referred to as the core loss weight, whose product with the specific loss in the leg represents the total iron loss. In a numerical example of a core with an unwidened yoke, the losses become 13.5 per cent lower than obtained under the assumption of a uniform field. By another application, it is shown that a widening of the yokes permits only a relatively small reduction in losses.

48-19—Electrical Insulation Deterioration Treated as a Chemical Rate Phenomenon; *Thomas W. Dakin. 25 cents.* The basis is presented for a more accurate interpretation of the results of physical-type tests to measure the thermal aging of insulation, together with a more accurate method of applying the results of such tests to predicting insulation deterioration in practice. As the observed physical changes during thermal aging are the result of internal chemical changes in organic material, it is shown that the theory of chemical reaction rates can be applied to analyze experimental data on aging. The approximate 7-degree to 10-degree rule for the temperature coefficient of deterioration rate is replaced by a more accurate theoretical expression. Various examples of insulation life tests are analyzed, using the graphical methods outlined in the paper. The chemical rate theory interpretation of thermal aging offers a more satisfactory method for extrapolating the results of limited aging tests of insulating materials so they can be applied to predicting amounts of thermal aging in high temperature cycles.

48-20—Terratex: A Thin, Flexible, Inorganic Insulation; *T. R. Walters (M '39). 20 cents.* An account is given of the development of a thin, totally inorganic paper-like sheet being produced in limited amounts on a pilot-plant basis. This sheet fills a gap in the class *B* insulation field where the designer is limited by the small number of useful materials. Made in thicknesses from 1.5 to 10 mils, most use has been made of the 3-mil thickness for wire covering. A dielectric strength approximately twice that of varnished glass or felted asbestos insulated wire is obtained. Other uses are for layer insulation, mica backing, and mica substitution. Thermal aging at 175 degrees centigrade, dielectric, and physical data are presented. Four years of service experience in dry-type transformers have shown no defects. This new type of dielectric possesses an unusual combination of dielectric strength, thermal life, and incombustibility, which may be used by the designer to obtain either improved space factor, or a higher factor of safety.

Transmission and Distribution

48-3—Location of Gas Leaks in Pipe-Encased Gas Pressure Cable Lines; *John D. Piper. 35 cents.* When gas is used as the pressure medium in pipe-encased cable lines, in contact with either the insulation or a sheath, a problem arises of locating gas leaks, should any develop, in the pipe line or auxiliaries. The use of nitrogen and the low rate of tolerable leak precluded the employment of usual methods and made development of a suitable one necessary. The method developed consists of three steps. The first locates the leak to the affected stop section; the second, to the affected joint section; and the third to the affected spot. The first employs manometers at stop joints; the second and third, a tracer gas, consisting of five per cent by volume of carbon dioxide in nitrogen, handled by unique techniques. The method has been used successfully in locating leaks in terminals, and a simulated leak in the pipe line, of a gas-pressure cable.

48-25—Transient Shaft Torques in Turbine Generators Produced by Transmission Line Reclosing; *J. W. Batchelor (M '47), D. L. Whitehead (A '41), J. S. Williams (A '41). 25 cents.* The increasing use of high-speed reclosing tie lines as principal components in power transmission systems has introduced the necessity of evaluating transient shaft torques that develop in turbine generators during switching operations, and justifies the presentation of an integrated method of electrical and mechanical torque analysis. The theory of this problem has been presented previously, as have been some solutions of typical problems involving a single machine synchronized with a large system through no-loss circuits. This paper extends the theory to those instances which may include resistance components in the network elements, and paralleling tise between machine and system. The solution of this problem in critical or borderline cases can be accomplished with satisfactory speed and thoroughness only by the electrical analogue computer, or with an equivalent electromechanical calculating device. Conventional calculating methods are laborious and do not encourage a sufficiently wide range of investigation. Most solutions also will be facilitated by a modified form of a-c calculator stability study. The methods presented for determining transient shaft torque are applicable to the synchronization of machines by manual control, or to synchronization initiated by automatic operation of circuit reclosing devices.

INSTITUTE ACTIVITIES

"Mining and Steel"—Theme of Winter General Meeting

Plans are practically complete for the winter general meeting which is being held this year in Pittsburgh, Pa., January 26–30, 1948. Full advantage has been taken of this location as "mining and steel" will be the theme for the industry sessions. A broad program covering practically the entire range of Institute technical activities has been co-ordinated with inspection trips to various industries. A general session will be held on Wednesday morning with a feature talk to interest many members. At this session the Edison Medal will be presented. The smoker and dinner-dance will be held as usual. In addition a special womens' program will be arranged. Headquarters for the meeting will be in the Hotel William Penn. Room reservations should be made early.

TECHNICAL SESSIONS AND CONFERENCES

Some 52 technical sessions and conferences have been distributed evenly during the five days of the week. Subject matter will be presented in practically every branch of technical activities. In the industrial field sessions highlighting "mining and steel" will deal with power supply, power distribution, and the specialized applications in the mining, steel, and glass industries. In the steel session on Tuesday morning, a descriptive talk on the Irvin works will serve as an introduction to a trip to the works in the afternoon.

In the field of power, a series of papers will be presented in one of the switchgear sessions on Tuesday afternoon describing short-circuit tests on 230-kv circuit breakers at Grand Coulee which have about three times the interrupting capacity of any previous breakers. On the Wednesday afternoon trip to the Westinghouse Electric Corporation's East Pittsburgh works, it is expected one of these circuit breakers may be seen in operation. Another session on capacitors will present a series of papers describing a large 66-kv 10,000-kva series capacitor recently installed by the Duquesne Light Company to provide voltage regulation. This session will serve as an introduction to an inspection of the installation on Thursday morning. In a session on extra-high-voltage cables, a series of papers will describe several of the newest installations of pipe-type cables.

In the realm of communications, science, and research, sessions are scheduled throughout the week dealing with new materials, electronic applications, communication components and techniques, facsimile and magnetic recording, communication switching systems, synthetic crystals, and radio relay systems.

INSPECTION TRIPS

Eleven inspection trips to various industries in the vicinity of Pittsburgh have been scheduled at specific times during the meeting. These trips have been listed in the schedule of events, and there will be a registration fee of 50 cents for each trip to defray transportation expenses except for the Tidd Line inspection trip which will be $2 per person per trip. A brief description of these trips was published last month (*EE, Dec '47, p 1231*). In addition to the trips listed last month, inspections of the Tidd 500-kv test lines and power station have been arranged for Monday and Friday afternoons. At this installation, which marks a milestone in the progress of higher voltage power transmission, may be seen the test equipment including lines, towers, transformers, lightning arresters, and testing devices. In addition, the newest power plant of the American Gas and Electric Company's system will be open for inspection.

In addition to the foregoing trips, arrangements may be made to visit the H. J. Heinz plant on any day, the planitarium on any evening, and the inclined railroad at any time. The University of

Night view of the city of Pittsburgh, Pa., locale of the 1948 AIEE winter general meeting

Schedule of Events

Monday, January 26

9:00 a.m.	Registration
9:30 a.m.	Electronic and resistance heating
	Applications in the steel industry
	Relays
	Instruments for radiation measurements
	Symposium on new materials
1:30 p.m.	Trip to Copperweld Steel Company
	Trip to Tidd 500-kv test lines and power station
2:00 p.m.	Power supply to steel mills
	Industrial control
	Conference on relays
	Transformers
	Electronic instruments

Tuesday, January 27

9:30 a.m.	Trip to Pittsburgh Plate Glass Company
	Trip to Springdale power plant
	Steel
	Material handling
	Switchgear I
	Electric machinery
	Electronics
	Symposium on railroad electrification
1:30 p.m.	Trip to Irvin Steel Works
2:00 p.m.	Machine tools
	Switchgear II
	Telemetering
	High-frequency measurements
	Heavy traction
	Some new electronic devices and applications
6:30 p.m.	Smoker

Wednesday, January 28

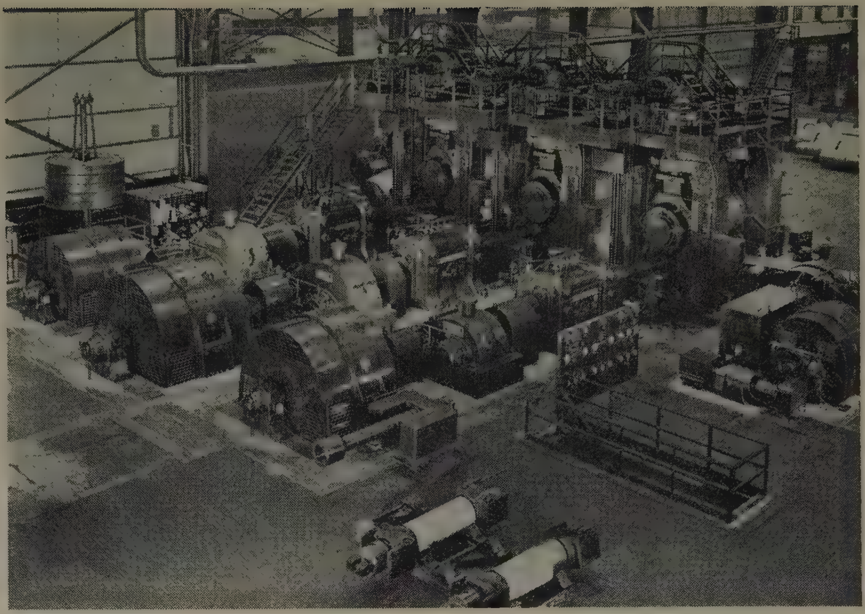
10:00 a.m.	General session
	Edison Medal presentation
1:30 p.m.	Trip to Westinghouse Electric Corporation, East Pittsburgh
	Trip to Dravo Shipyard
2:30 p.m.	Power distribution in steel mills and mines
	Capacitors
	Conference on relays
	Basic sciences
	Communication components and techniques
	Light traction
7:00 p.m.	Dinner-dance

Thursday, January 29

9:30 a.m.	Board of directors' meeting
	Trip to 66-kv 10,000-kva series capacitor installation
	Power distribution in mining and glass industry
	Metallic rectifiers
	Arc welding
	Extra-high-voltage cable systems
	Conference on applied mathematics
	Facsimile
12:30 p.m.	Board of directors' luncheon
1:00 p.m.	Trip to Alcoa Research
1:30 p.m.	Trip to Bureau of Mines—explosive testing station
2:00 p.m.	Resistance welding
	Mechanical rectifiers
	Fault limiting devices
	Conference on network circuit theory
	Magnetic recording
	Conference on safety

Friday, January 30

9:30 a.m.	General applications to mining
	Electrothermal processes
	Excitation and speed governing
	Conference on substations
	Servomechanisms
	Synthetic crystals
1:30 p.m.	Trip to Tidd 500-kv test lines and power station
2:00 p.m.	Electric cables in mines
	General system engineering
	Radio relay systems
	Electric heating of houses
	Industrial control



Three stand tandem cold-reduction mill at the Irvin Works, Carnegie-Illinois Steel Corporation, scheduled for a joint inspection trip of the AIEE and the Association of Iron and Steel Engineers during the 1948 AIEE winter general meeting

Pittsburgh Cyclotron may be seen at 2:30 p.m., Tuesday, Wednesday, and Thursday by registration in advance.

SMOKER

This, the most popular event of the winter general meeting, will be held Tuesday evening January 27th in the William Penn Hotel. Dinner will start at 6:30 p.m. with an array of topnotch vaudeville acts following. Tables for dinner will accommodate four or ten persons. Price for tickets will be $7.50 per person. Because the seating capacity is limited, early reservations are suggested.

DINNER-DANCE

This year marks the revival of the winter general meeting formal dinner-dance which will be held in the ballroom of the William Penn Hotel, Wednesday evening, January 28th. Dinner will start at 7:00 p.m. followed by dancing and a floor show. Tables for the dinner and dance will accommodate four or ten persons; price for the tickets will be $6 per person.

Reservations should be addressed to M. S. Angier, chairman of the entertainment committee, P. O. Box 1017, Pittsburgh 30, Pa.

WOMENS' ENTERTAINMENT

A varied and interesting program has been prepared for the women which includes a luncheon, teas, dinners, tours of the city including the Block House and inclined railway, trips to H. J. Heinz and the Buhl Planetarium and Institute of Popular Science, and an afternoon at the University of Pittsburgh's Cathedral of Learning to see the unique Nationality Rooms, Heinz Chapel, and the Stephen Foster Memorial.

(*Continued on page 93*)

Future AIEE Meetings

Winter General Meeting
William Penn Hotel, Pittsburgh, Pa.
January 26–30, 1948

AIEE Conference on Electron Tubes for Instrumentation and Industrial Use
Benjamin Franklin Hotel, Philadelphia, Pa.
March 29–31, 1948

Great Lakes District Meeting
Des Moines, Iowa
April 1–3, 1948
(*Final date for submitting papers—January 16*)

North Eastern District Meeting
New Haven, Conn.
April 28–30, 1948
(*Final date for submitting papers—February 11*)

Summer General Meeting
Palace of Fine Arts, Mexico City, Mexico
June 21–25, 1948
(*Final date for submitting papers—February 1*)

Pacific General Meeting
Spokane, Wash.
August 24–27, 1948
(*Final date for submitting papers—June 10*)

Middle Eastern District Meeting
Hotel Statler, Washington, D. C.
October 5–7, 1948
(*Final date for submitting papers—July 21*)

Midwest General Meeting
Schroeder Hotel, Milwaukee, Wis.
October 18–22, 1948
(*Final date for submitting papers—August 3*)

Southern District Meeting
Birmingham, Ala.
November 3–5, 1948
(*Final date for submitting papers—August 20*)

Tentative Program, Winter General Meeting,

Monday, January 26

9:00 a.m. Registration

9:30 a.m. Electronic and Resistance Heating

CP.* Measurement of Interference from Radio-Frequency Heating Equipment. *G. H. Brown,* Radio Corporation of America

CP.* Shielding of Radio-Frequency Heating Equipment. *J. E. Eiselein,* Radio Corporation of America

48-10. Federal Communications Commission Diathermy Design for Low-Harmonic Radiation and Good Frequency Stability. *E. W. Chapin, W. K. Roberts, M. C. Mobley, Jr.,* Federal Communications Commission

48-17. Some Economic Aspects of Radio-Frequency Heating. *L. M. Duryee,* The Connecticut Light and Power Company

CP.* Simple Means for the Prediction of Generator Performance in Induction Heating. *Eugene Mittelman,* consulting engineer and physicist

CP.* Industrial Electric Resistance Heating. *L. P. Hynes,* electrical and mechanical engineer

9:30 a.m. Applications in the Steel Industry

CP.* Pin-Hole Detectors for the Steel Industry. *M. D. Bassett, L. U. C. Kelling,* General Electric Company

48-100. An X-Ray Thickness Gauge for Hot-Strip Rolling Mills. *C. W. Clapp, R. V. Pohl,* General Electric Company

48-14. X-Ray Thickness Gauge for Cold Rolled Strip Steel. *W. N. Lundahl,* Westinghouse Electric Corporation

9:30 a.m. Relays

48-6. Bibliography of Relay Literature, 1944–1946. *Project Committee on Relay Bibliography*

48-12. Relaying Difficulties Disclosed by Staged Fault Tests. *W. A. Morgan, Byron Evans,* Bureau of Reclamation

9:30 a.m. Instruments for Radiation Measurements

CP.* High-Speed Counters. *J. L. Lawson,* General Electric Company

CP.* Crystal Counters. *R. Hofstader,* Princeton University

CP.* Photomultipliers. *J. W. Coltman,* Westinghouse Electric Corporation

CP.* Geiger-Müller Counters. *L. F. Curtiss,* National Bureau of Standards

CP.* Vibrating Reed Electrometer. Speaker from Argonne Laboratories

9:30 a.m. Symposium on New Materials

This program will include a discussion of new insulating and dielectric material, new metals, and alloys used as conducting magnetic or semiconducting bodies. Many of these materials are the result of wartime research and development. They are distinguished by unusual properties or availability. Some of the materials will have a profound effect on the future design of electric equipment.

2:00 p.m. Power Supply to Steel Mills

CP.* Effect of Load Swings on Frequency and Tie-Line Load Control. *T. E. Purcell,* Duquesne Light Company

CP.* Economics of Process Steam Generation. *Mr. Zelley,* John A. Roeblings and Sons

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—PAMPHLET reproductions of author's manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.

—ABSTRACTS of papers listed appear on pages 76–87 of this issue.

—PRICES and instructions for procuring advance copies of these papers accompany the abstracts. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in five-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the technical program committee ultimately will be published in PROCEEDINGS and TRANSACTIONS; essential substance of many will appear in ELECTRICAL ENGINEERING.

48-15. Suddenly Applied Loads Carried by a Variable-Ratio Synchronous-Induction Frequency Changer. *A. G. Darling,* General Electric Company; *G. A. Kaufman,* Jones and Laughlin Steel Corporation

CP.* Power Generation for Industrial Plants. *F. D. Troxel,* Sargent and Lundy

2:00 p.m. Industrial Control

48-98. The Liquid Rheostat for Speed Control of Wound-Rotor Induction Motors. *G. L. McFarland William Alvarez,* General Electric Company

CP.* A New Liquid Rheostat for Steel Mill Use. *T. B. Montgomery,* Allis-Chalmers Manufacturing Company

48-11. Improvements in Rolling Mill Preset, Screw-Down Controllers. *J. D. Leitch, C. A. Schurr,* The Electric Controller and Manufacturing Company

2:00 p.m. Conference on Relays

2:00 p.m. Transformers

48-18. Influence of the Core Form Upon the Iron Losses of Transformers. *G. M. Stein,* Westinghouse Electric Corporation

48-19. Electrical Insulation Deterioration Treated as a Chemical Rate Phenomenon. *T. W. Dakin,* Westinghouse Electric Corporation

48-20. Terratex—a Thin, Flexible, Inorganic Insulation. *T. R. Walters,* General Electric Company

2:00 p.m. Electronic Instruments

CP.* Fail-Safe Operation of Electronic Circuits. *G. D. Hanchett,* RCA Manufacturing Company

48-21. Electronic Circuits of a Supersonic Reflectoscope, *R. B. DeLano, Jr.,* Sperry Products, Inc.

48-96. Oil Film Thickness Indicator for Journal Bearings. *M. L. Greenough,* National Bureau of Standards

48-9. D-C Amplifier Stabilized for Zero and Gain. *A. J. Williams, Jr., R. E. Tarpley, W. R. Clark,* Leeds and Northrup Company

CP.* High-Voltage Cathode-Ray Oscilloscopes for Surge Testing. *W. G. Fockler,* Allen B. DuMont Laboratories, Inc. (Also see papers 48-13 and 48-14 in steel session)

Tuesday, January 27

9:30 a.m. Steel

Talk on Irvin Works of Carnegie-Illinois Steel Company to provide introduction to inspection trip. *M. W. Reed,* vice-president, engineering, Carnegie-Illinois Steel Company

48-22. Electric Equipment for Cold Strip Reduction Mills. *W. E. Miller,* General Electric Company

CP.* WK^2 Aspect of High-Speed Mills. *T. B. Montgomery,* Allis-Chalmers Manufacturing Company

9:30 a.m. Material Handling

CP.* Electric Drives with Fluid Couplings for Material Handling Equipment. *F. W. Atz,* Link Belt Company

CP.* Features of New 600 Series Mill Motor for Material Handling Applications. *C. B. Hathaway,* Westinghouse Electric Corporation

CP.* Selection of D-C Series Motors for Crane Applications. *M. A. deFerranti,* General Electric Company

9:30 a.m. Switchgear I

48-23. A Study of A-C Arc Behavior Near Current Zero by Means of Mathematical Models. *T. E. Browne, Jr.,* Westinghouse Electric Corporation

48-24. A Compressed Air Circuit Breaker for 23-Kv Arc Furnace Duty. *H. M. Wilcox, B. P. Baker,* Westinghouse Electric Corporation

48-26. Arcing Fault Currents in Low-Voltage A-C Circuits. *C. F. Wagner, L. L. Fountain,* Westinghouse Electric Corporation

9:30 a.m. Rotating Machinery

48-27. Steady-State Equivalent Circuits of Synchronous and Induction Machines. *Gabriel Kron,* General Electric Company

48-28. Induction Machinery Theory Relating to a Special Feed-Back Generator. *H. Vickers,* England

48-29. The Single-Phase Synchronous Machine. *I. A. Terry,* General Electric Company; *B. L. Robertson,* University of California

48-30. Performance of the Single-Phase Synchronous Machine. *B. L. Robertson, T. A. Rogers,* University of California

48-31. A Study of the 3-Phase Commutator Armature With Six Adjustable Brushes. *P. W. Franklin.* Continental Electric Company

9:30 a.m. Electronics

48-32. Quadrature Operation of Filamentary Thermionic Gas Tubes. *V. L. Holdaway,* Bell Telephone Laboratories, Inc.

48-33. A Method for the Measurement of the Deionization and Ionization Times of Thyratron Tubes. *Milton Birnbaum,* Washington, D. C.

48-34. Printed Circuit Developments. *Cledo Brunetti,* National Bureau of Standards

48-35. Performance of Pumped Ignitron Rectifiers. *C. C. Herskind, E. J. Remscheid,* General Electric Company

9:30 a.m. Symposium on Railroad Electrification

48-36. Comparative Operating Results of Steam, Diesel-Electric, and Electric Motive Power on the Great Northern Railway Electrification. *J. F. N. Gaynor,* Great Northern Railway

Pittsburgh, Pa., January 26-30, 1948

48-97. Power Costs and the Contribution of Existing Transmission Networks Towards Cost Reduction of Power for Electrification of Main Line Railroads with Moderate Traffic. *Llewellyn Evans*, Tennessee Valley Authority

48-37. Railroad Electrification Energy Conversion and Transmission Costs. *R. L. Kimball, J. G. Holm*, Gibbs and Hill, Inc.

48-38. Are the Overhead Distribution Costs Retarding Railroad Electrification? *L. W. Birch*, Ohio Brass Company

48-39. Shunt Capacitor Installation for Single-Phase Railway Service. *H. F. Brown*, New York, New Haven, and Hartford Railroad; *R. L. Witzke*, Westinghouse Electric Corporation

2:00 p.m. Machine Tools

CP.* Electrical Engineering in Machine Tool Industry. *A. L. Krause*, Brown and Sharpe Company

CP.* New Types of Adjustable Speed Motors for Machine Tools. *W. M. Elder*, Westinghouse Electric Corporation

CP.* Electric Drives for Planers. *J. W. Harper*, General Electric Company

CP.* (To be announced)

2:00 p.m. Switchgear II

48-40. A 230-Kv 3-Cycle Oil Circuit Breaker for Extra-Heavy Arc Rupturing Duty. *W. M. Leeds, G. B. Cushing*, Westinghouse Electric Corporation

48-41. Unusual Performance of Standard 230-Kv Impulse and Tank-Type Oil Circuit Breakers on Field Tests. *E. B. Rietz*, General Electric Company

48-42. Field Tests for Development of 10-Million-Kva 230-Kv Oil Circuit Breakers for Grand Coulee Power Plant. *C. L. Killgore, W. H. Clagett*, United States Bureau of Reclamation

48-43. Performance Tests of the AEG (German) Free-Jet Air-Blast 2,500-Megavolt Ampere Reclosing Circuit Breaker. *Alexander Dobjikov, C. C. Diemond*, Bonneville Power Administration

2:00 p.m. Telemetering

48-44. New Devices Derived from a Torque Balance Telemeter. *W. H. Burnham*, General Electric Company

48-45-ACO. Modern Telemetering System—Providing Kilowatt Indication, Recording, Integration, and Demand.** *R. G. Meyerand*, Union Electric Company of Missouri

48-46. A Faster Telemeter for Carrier Current Channels. *E. E. Lynch, H. C. Thomas, G. S. Lunge*, General Electric Company

2:00 p.m. High-Frequency Measurements

48-47. A Direct Reading D-C Bridge for Microwave Power Measurements. *H. J. Carlin, Judd Blass*, Polytechnic Institute of Brooklyn

48-48. A Broad-Band Signal Generator. *T. P. Hahn, John Ebert, W. A. Lynch*, Polytechnic Research and Development Company

48-49. Microwave Frequency Measurements and Standards. *B. F. Husten, Harold Lyons*, National Bureau of Standards

48-50. A Standard of Attentuation for Microwave Measurements. *R. E. Grantham, J. J. Freeman*, National Bureau of Standards

2:00 p.m. Heavy Traction

48-51-ACO. A-C Air Conditioning for Railroad Passenger Cars.** *H. H. Hanft*, Westinghouse Electric Corporation

48-52. Responsive Devices on Diesel-Electric Locomotives. *A. V. Johansson*, General Electric Company

48-53. A Unique Application of the Wheatstone Bridge to High-Speed Train Braking. *C. M. Hines*, Westinghouse Air Brake Company

48-54. Electric Locomotives with Identical Basic Components. *W. A. Brecht, Charles Kerr, Jr.*, Westinghouse Electric Corporation

2:00 p.m. Some New Electronic Devices and Applications

CP.* The Measurement of Large Pulse Currents. *N. Rochester, D. L. Stevens*, Sylvania Electric Products, Inc.

CP.* New Cathode-Ray Oscillograph Accessories and Applications. *P. S. Christaldi*, Allen B. DuMont Laboratories

CP.* The Motion Detector—An Application of Microwaves. *W. C. White*, General Electric Company

Wednesday, January 28

10:00 a.m. General Session

Edison Medal presentation

2:00 p.m. Power Distribution in Steel Mills and Mines

CP.* Selection of Voltage for Steel Mill Power Systems. *H. J. Finison*, General Electric Company

CP.* Short-Circuit Currents in D-C Systems. *William Deans*, I-T-E Circuit Breaker Company

48-26. Arcing Fault Currents in Low-Voltage A-C Circuits. *C. F. Wagner, L. L. Fountain*, Westinghouse Electric Corporation

48-16. Features of a New A-C Bus Design. *R. N. Wagner*, Aluminum Company of America

2:00 p.m. Capacitors

48-55. 10,000-Kva Series Capacitor Improves Voltage on 66-Kv Line Supplying Large Electric Furnace Load. *B. M. Jones, J. M. Arthur, C. M. Stearns*, Duquesne Light Company; *A. A. Johnson*. Westinghouse Electric Corporation

48-56. Design and Layout of 66-Kv 10,000-Kva Series Capacitor Substation. *G. B. Miller*, Duquesne Light Company

48-57. Design and Protection of 10,000-Kva Series Capacitor for 66-Kv Transmission Line. *A. A. Johnson, R. E. Marbury*, Westinghouse Electric Corporation; *J. M. Arthur*, Duquesne Light Company

2:00 p.m. Conference on Relays

2:00 p.m. Basic Sciences

48-1-ACO. A Critical Analysis of Voltage Conventions and Double-Subscript Notations.** *M. B. Reed, W. A. Lewis*, Illinois Institute of Technology

48-58. Hystero-Viscosity in Silicone. *M. G. Malti*, Cornell University; *A. K. Chatterjee*, University of Illinois

48.68. Attenuator Materials, Attenuators, and Terminations for Microwaves. *G. K. Teal, M. D. Rigterink, C. J. Frosch*, Bell Telephone Laboratories, Inc.

48-69. Insulation Breakdown as a Function of Area. *L. R. Hill, P. L. Schmidt*, Westinghouse Electric Corporation

48-70-ACO. Solutions of the Mathieu Equation.** *H. J. Gray, Richard Merwin, J. G. Brainerd*, University of Pennsylvania

2:00 p.m. Communication Components and Techniques

48-59. Recent Improvements in Loading Apparatus for Telephone Cables. *S. G. Hale*, Bell Telephone Laboratories, Inc.; *A. L. Quinlan*, Western Electric Company; *J. E. Ranges*, Bell Telephone Laboratories, Inc.

48-60. A Telegraph Signal Analyzer. *G. L. Erickson*, The Western Union Telegraph Company

48-8. An Electro-Acoustical Locating System *E. A. Walker*, The Pennsylvania State College

48-99. The Director for Automatic Telephone Switching Systems. *Arthur Bessey Smith*, Associated Electric Laboratories, Inc.

CP.* The McBerty System. North Electric author

CP.* CRX Switching System (including film)

2:00 p.m. Light Traction

48-62-ACO. Electrically Propelled Vehicles Most Economical in City Transit.** *G. M. Woods*, Westinghouse Electric Corporation

48-63. Trolley Coach Distribution System. *G. R. McDonald*, General Electric Company

48-64. Three-Compartment Articulated Cars for Test on Rapid Transit Division, Chicago Transit Authority. *H. A. Otis*, Chicago Transit Authority

Thursday, January 29

9:30 a.m. Power Distribution in the Mining and Glass Industry

CP.* Power Supply for a Glass Plant. *J. E. Arberry*, Pittsburgh Plate Glass Company

CP.* Power Supply for Strip Mining. *Albert Brown*, Philadelphia and Reading Coal and Iron Company

48-65-ACO. The New D-C Sectionalization Application Standards.** *M. W. Pennybacker, Donald J. Baker*, I-T-E Circuit Breaker Company

9:30 a.m. Metallic Rectifiers

48-66. Twenty-five Years of Copper-Oxide Rectifiers. *L. O. Grondahl*, Union Switch and Signal Company

Discussion

9:30 a.m. Arc Welding

CP.* Electric Power Supply Problems of Inert Gas Arc Welding. *A. U. Welch*, General Electrict Company

CP.* Electronic Equipment for Submerged Malt Welding Processes. *J. J. Kratz*, Linde Air Products Company

CP.* Power Supply for Farm Welders. *A. A. Mathews, G. V. Patterson*, Ohio Power Company

9:30 a.m. Extra-High-Voltage Cable Systems

48-71. A 138,000-Volt Polyethylene-Sheathed Compression Cable—Pipe-Line Type. *J. E. McCormack, C. T. Hatcher*, Consolidated Edison Company of New York, Inc.; *K. S. Wyatt, W. A. Del Mar, E. J Merrell, J. H. Palmer*, Phelps Dodge Copper Products Corporation; *E. F. DeTurk*, Long Island Lighting Company

48-72. The 115-Kv High-Pressure Oil-Filled Pipe Cable Installation at New Orleans, La. *W. R. Bullard*, Ebasco Services, Inc.; *A. D. Pettee*, General Cable Corporation; *G. L. Rhodes*, New Orleans Public Service, Inc.

48-73. Thermal Characteristics of a 120-Kv High-Pressure Gas-Filled Cable Installation. *W. D. Sanderson, J. Sticher*, Detroit Edison Company; *M. H. McGrath*, General Cable Corporation

48-3. Location of Gas Leaks in Pipe-Encased Gas-Pressure Cable Lines. *J. D. Piper*, The Detroit Edison Company

48-7. Use of Reduced-Scale Models for the Solution of Cable Temperature Problems—II. *Andrew Gemant, Joseph Sticher*, The Detroit Edison Company

9:30 a.m. Conference on Applied Mathematics

Tentative Winter Program *(Continued)*

9:30 a.m. Facsimile

48-74. Western Union Teletape Facsimile. *L. G. Pollard*, The Western Union Telegraph Company

CP.* Picture Transmission Over Wire Lines. *I. E. Lattimer*, American Telephone and Telegraph Company

2:00 p.m. Resistance Welding

CP.* Rhoades' Subcommittee Report on Power Supply for Resistance Welding Machines

CP.* Resistance Welding in the Steel Mill. *Mr. Riley*, Taylor-Winfield Corporation

CP.* What Is Resistance Welding? Speaker from Resistance Welding Manufacturer's Association

CP.* Postwar Welding of Aluminum

2:00 p.m. Conference on Mechanical Rectifiers

CP.* History of Mechanical Rectifiers. *J. T. Thwaites*, Canadian Westinghouse Company

CP.* The Problem of Commutation. *Walther Richter*, Allis-Chalmers Manufacturing Company

CP.* The German Mechanical Rectifier. *Otto Jensen*, I-T-E Circuit Breaker Company

CP.* Commutating Reactors. *B. D. Bredford*, General Electric Company

2:00 p.m. Fault Limiting Devices

47-237. Present-Day Grounding Practices on Power Systems. *AIEE Subject Committee on Present-Day Grounding Practices*, late R. D. Evans, chairman

48-78. Survey of Lightning Protective Equipment for Rotating A-C Machines. *AIEE Lightning Protective Devices Subcommittee*

48-79. Expulsion-Type Lightning Arresters Impulse Sparkover Volt-Time Characteristics. *AIEE Lightning Protective Devices Subcommittee*

2:00 p.m. Magnetic Recording

48-75. Magnetic Recording Tapes. *Marvin Camras*, Armour Research Foundation

48-76. Turn-in-Gap Erase Head for Magnetic Recorders Providing Intense High-Frequency Fields. *D. E. Wiegand, R. E. Zenner*, Armour Research Foundation

48-77-ACO. The Practical Application of Supersonic Bias in Magnetic Recording.** *H. A. Howell*, Indiana Steel Products Company

CP.* Demonstration of Magnetic Recording

2:00 p.m. Conference on Safety

Selling the Public on Safety from Low-Voltage Electrical Hazards

1. Motion picture: "The Shocking Truth," a technicolor film on low-voltage hazards. Courtesy of The Liberty Mutual Insurance Company

2. Symposium on how to enforce and caution the public against the hazards of low-voltage shocks

2:00 p.m. Conference on Network Circuit Theory

Friday, January 30

9:30 a.m. General Applications to Mining

CP.* Conversion Equipment for Mine Power. *W. R. Morton*, General Electric Company

CP.* Motors and Controls for Underground Mining Machines. *D. E. Renshaw*, Westinghouse Electric Corporation

48-80. Electrical Control Problems in Coal Mines. *C. O. Wood*, Goodman Manufacturing Company

9:30 a.m. Electrothermal Processes

CP.* Electrode Control and Associated Operating Mechanisms. *E. A. Hanff*, Swindell-Dressler Corporation

CP.* Experience in Design and Control of Ferro-Alloy Furnaces. *F. V. Andreae*, Southern Ferro Alloys Company

CP.* Electrode Control for Arc Furnaces. *C. E. Valentine, E. H. Browning, Jr.*, Westinghouse Electric Corporation

CP.* Electric Equipment and Operation of Graphitizing Furnaces. *F. M. Baxandall, E. R. Cole*, Dow Chemical Company

CP.* Electrode Control for Arc Furnaces. *A. R. Oltrogge*, General Electric Company

9:30 a.m. Excitation and Speed Governing

48-2. Generator Stability at Low Excitation. *E. L. Michelson, L. F. Lischer*, Commonwealth Edison Company

48-81. Underexcited Operation of Turbine-Generators. *C. G. Adams, J. B. McClure*, General Electric Company

48-82. Rototrol Excitation Systems. *J. E. Barkle, C. E. Valentine*, Westinghouse Electric Corporation

48-83. Main Exciter Rototrol Excitation for Turbine Generators. *C. Lynn, C. E. Valentine*, Westinghouse Electric Corporation

48-90. Precise Turbine Governor. *H. E. Warren*, Lombard Governor Corporation

48-89-ACO. Hydraulic Turbine Governor Specification.** *E. B. Strowger*, Buffalo Niagara Electric Corporation

48-4-ACO. Recommended Specification for Speed-Governing of Steam Turbines Intended to Drive Electric Generators Rated 500 Kw and Up.** *Joint AIEE-ASME Committee on a Recommended Specification for Prime Mover Speed Governing;* M. J. Steinberg, chairman

48-5-ACO. Recommended Specification for Speed-Governing of Hydraulic Turbines Intended to Drive Electric Generators.** *Joint AIEE-ASME Committee on a Recommended Specification for Prime Mover Speed Governing;* M. J. Steinberg, chairman

9:30 a.m. Conference on Substations

9:30 a.m. Servomechanisms

48-84. The Effect of Coulomb Friction on the Performance of Servomechanisms. *G. D. McCann, F. C. Lindvall, C. H. Wilts*, California Institute of Technology

48-85. Graphical Analysis of Control Systems. *W. R. Evans*, Washington University

9:30 a.m. Synthetic Crystals

48-86. Crystal Filters Using Ethylene Diamine Tartrate in Place of Quartz. *E. S. Willis*, Bell Telephone Laboratories, Inc.

48-87. Design and Performance of Ethylene Diamine Tartrate Crystal Units. *J. P. Griffin, E. S. Pennell*, Bell Telephone Laboratories, Inc.

48-88. Growing Crystals of Ethylene Diamine Tartrate. *A. C. Walker, G. T. Kohman*, Bell Telephone Laboratories, Inc.

2:00 p.m. Electric Cables in Mines

CP.* Discussion of Electric Cable Practice in Coal Mines of Illinois. *C. C. Conway*, Consolidated Coal Company

CP.* Mechanical Experience With Trailing Cables on Mobile Mine Machinery. *G. W. Jones*, Logan County Coal Corporation

CP.* Safe Use and Installation of Electric Cables in Coal Mines. *T. R. Weichel*, Bureau of Mines

CP.* A Machinery Manufacturer Looks at Cable. *Frank Hugius*, Joy Manufacturing Company

CP.* Improvements in Mining Machine Cables. *R. A. Schatzel*, Rome Cable Company

CP.* Essential Characteristics of Design and Materials for Manufacturing Cables. *G. J. Andrews*, Simplex Wire and Cable Company

2:00 p.m. General System Engineering

CP.* Electric Power and Our National Defense. *W. L. Cisler*, The Detroit Edison Company

Symposium on Controllable Factors Affecting System Load:

CP.* Results of Frequency and Voltage Reduction Tests on an Isolated System. *C. B. Kelly*, United Light and Railways Service Company

CP.* Operating Tests of Voltage-Load Reductions. *D. P. Reed*, New England Power Company

CP.* Voltage and Frequency Reduction as Tools for Handling Emergency Capacity Conditions. *H. W. Phillips*, Pennsylvania-New Jersey Interconnection

CP.* Technical Approach as to the Effect of Voltage and Frequency Reductions on System Load. *J. E. McCormack*, Consolidated Edison Company of New York, Inc.

2:00 p.m. Radio Relay Systems

CP.* Television Radio Relay System. *William Forester*

CP.* Portable Television Studio to Transmitter Link. *C. A. Rosencrans*

48-91. A 150-Kc Carrier System for Radio Relay Applications. *J. E. Boughtwood*, Western Union Telegraph Company

48-92. Filters for a 150-Kc Carrier System. *R. C. Taylor*, The Western Union Telegraph Company

2:00 p.m. Electric Heating of Houses

48-93. The Heat Pump from the Utility's Point of View. *S. W. Andrews*, American Gas and Electric Service Corporation

CP.* Temperature Distribution and Effect of ICE Formation Around the Ground Coil of a Heat Pump. *A. D. Kafadar, R. A. Budenholzer, I. B. Fieldhouse*, Armour Research Foundation

CP.* Engine-Driven Heat Pumps. *K. W. Miller. N. C. Penfold*, Armour Research Foundation

CP.* Climatic and Usage Factors Affecting Heat Pump Selection. *D. W. McLenegan, G. W. Brown*, General Electric Company

48-95-ACO. Electric House-Heating Tests in Oregon.** *W. L. Sharp, A. E. Opdenweyer*, Portland General Electric Company

2:00 p.m. Industrial Control

CP.* Steel Mill Control Practices and Trends. *A. W. Schmitz*, General Electric Company

CP.* Two Overload Relays Versus Three on 3-Phase Systems. *K. Pinder*, E. I. du Pont de Nemours

CP.* Heavy Duty D-C Contactors—6,000 Amperes, 3,000 Amperes, and 1,500 Amperes. *R. M. Peeples, C. R. Peter*, Allis-Chalmers Manufacturing Company

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***CP:** Conference paper; no advance copies are available; not intended for publication in *TRANSACTIONS*

****ACO:** Advance copies only available; not intended for publication in *TRANSACTIONS*.

Speed-responsive devices on Deisel-electric locomotives such as the above will be discussed at the winter general meeting

(*Continued from page 89*)

ETA KAPPA NU RECOGNITION DINNER

The Eta Kappa Nu recognition dinner honoring outstanding young electrical engineers will be held Monday evening, January 26, in the Urban Room of the William Penn Hotel.

From 1936 through 1941, Eta Kappa Nu, national honorary electrical engineering society, presented an award to the most outstanding young electrical engineer of the year. The engineer, not more than ten years out of school and not over 35 years of age, was judged on his technical accomplishments, and social, cultural, and civic activities. The winner received a certificate and a small cup suitably inscribed, and his name was added to those appearing on a large cup kept at AIEE headquarters in New York, N. Y. The first evening of the AIEE winter meeting was usually the night of the dinner at which the winner and honorable mention recipients were announced. For obvious reasons the awards were suspended during the war years.

This year marks the renewal of the recognition award presentation. It will be an especially interesting event for awards will be presented to winners for the years 1942 through 1947. Six winners, and 15 honorable mentions will be announced. W. J. Lyman of the Duquesne Light Company is chairman of the Pittsburgh arrangement for this dinner.

HOTELS

The approximate rates of several Pittsburgh hotels were listed last month (*EE, Dec '47, p 1231*). Members are urged to make hotel reservations by writing directly to the hotel preferred. Although arrangements have been made for sufficient rooms for the number expected to attend, they will be held only if specifically reserved by those who will occupy them. Reservations should be made promptly.

ADVANCE REGISTRATION

Members should register in advance by filling in and mailing the advance registration card as soon as received in the mail. This will assist the committees in making arrangements and save time at the registration desk on arrival. A nonmember registration fee of $2 will be charged all nonmembers except members of the Association of Iron and Steel Engineers and members of the American Mining Congress, who have been invited to take part in the

Object of one winter general meeting inspection trip will be the 10,000-kva 66-kv series capacitor installed by the Duquesne Light Company near Shippingport, Pa.

AIEE PROCEEDINGS

Order forms for AIEE *PROCEEDINGS,* and abstracts of the papers included, have been published in *ELECTRICAL ENGINEERING* as listed below. Each section of *PROCEEDINGS* contains the full formal text of a technical paper including discussion, if any, as it will appear in the annual volume of *TRANSACTIONS. PROCEEDINGS* are issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 576–8; Jan '47, pp 82–3*), and are available to AIEE Associates, Members, and Fellows.

Meetings	Abstracts	PROCEEDINGS Order Forms
Winter	Jan '47, pp. 84–93; Feb. '47, pp 190–1	Feb '47, pp 33A and 34A
North Eastern District	Apr '47, pp 401–02	June '47, pp 55A and 56A
Summer General	June '47, pp 607–14; July '47, p 708	
Pacific General	Aug '47, pp 840–2	Dec '47, pp 55A and 56A
Middle Eastern District	Sept '47, pp 925–7	
Midwest General	Nov '47, pp 1125–8	

industry group sessions; Enrolled Students; and the immediate families of members.

COMMITTEES

The members of the general committee for the 1948 winter general meeting are: C. A. Powel, *chairman;* C. T. Sinclair, *vice-chairman;* L. N. Grier, *secretary-treasurer;* H. S. Fitch; Paul Frederick; J. R. MacGregor; A. C. Monteith. Subcommittee chairmen are: M. S. Angier, *entertainment;* R. L. Dunlap, *finance;* M. Getting, *publicity;* R. C. Gorham, *meetings and papers;* A. A. Johnson, *inspection and transportation;* B. M. Jones, *registration and information;* Mrs. G. A. Price, *ladies' entertainment;* C. M. Skooglund, *hotels.*

New Division Formed by AIEE Minnesota Section

Comprised of 60 AIEE members from Fergus Falls, Minn., and Fargo, Grand Forks, and Wahpeton, N. Dak., the Red River Valley Division of the Minnesota Section was formed at a meeting sponsored by the Minnesota Section in Fargo on November 21, 1947. J. H. Merriman (M '41) Minnesota Section chairman, presided.

A discussion of the operation of the local technical group by Carl Lethert (M '44) of the Northern States Power Company, Minneapolis, Minn., and a technical talk on "System Operation" by S. N. Witts (M '42) also of the Northern States company, were among the features of the meeting. Other speakers included A. G. Dewars (F '44) past AIEE vice-president, and Professor John Kuhlmann (M '27) associate professor of electrical design at the University of Minnesota.

Division officers elected at the meeting were: *chairman,* H. S. Dixon (M '43) head of the electrical engineering department, North Dakota Agricultural College, Fargo; *vice-chairman,* T. C. Wright (M '46) president, Otter Tail Power Company, Fergus Falls; and *secretary-treasurer,* M. R. Hughes (M '47) Fargo.

The Red River Valley Division met again on December 6, jointly with the Fargo Engineers Club.

Joseph Slepian Chosen as 1947 Edison Medalist

Joseph Slepian (F '27) associate director, research laboratory, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been selected to receive the Edison Medal, highest AIEE award, for the year 1947 for "his practical and theoretical contributions to power systems through circuit analysis, arc control, and current interruption."

Doctor Slepian, 37th winner of the medal, will be presented with the award on January 28, 1948, during the AIEE winter general meeting in Pittsburgh, Pa.

A biographical sketch of Doctor Slepian will appear in an early issue of *ELECTRICAL ENGINEERING.*

In Memoriam

WILLIAM ELGIN WICKENDEN

WITH deep sorrow, the board of directors of the American Institute of Electrical Engineers records the death, on September 1, 1947, of William Elgin Wickenden, 58th president of the Institute, and an outstanding leader in engineering education and related fields.

He was born in Toledo, Ohio, on December 24, 1882, and received his degree of bachelor of science from Denison University in 1904. After one year as instructor in applied electricity at the Mechanics Institute, Rochester, N. Y., he joined the faculty of the University of Wisconsin as assistant in physics, becoming instructor in electrical engineering the next year. In 1909, he went to the Massachusetts Institute of Technology as assistant professor of electrical engineering, and was advanced to associate professor in 1914.

He was appointed personnel manager of the Western Electric Company, New York, N. Y., in 1918, and became assistant vice-president of the American Telephone and Telegraph Company in 1921. During the period 1923–29, he served as director of the investigation of engineering education under the joint sponsorship of the Society for the Promotion of Engineering Education (now American Society for Engineering Education) and the Carnegie Corporation, and, in 1929, became president of the Case School of Applied Science. His retirement became effective on the day of his death.

He served as a member of several Institute committees; chairman of the Cleveland Section in 1936; vice-president, 1943–45; and president, 1945–46. He was a member of and active in numerous other organizations, having served as vice-president of the American Association for the Advancement of Science, vice-chairman of the American Council on Education, president of the Ohio College Association, chairman of the Ohio Regional Labor Board, and president of the Society for the Promotion of Engineering Education. He received the Lamme Medal of the latter society in 1935. Between 1926 and 1933, he received eight doctor's degrees, including engineering, science, laws, and humane letters.

In both engineering education and scientific and engineering society activities, Doctor Wickenden was an inspiring leader. He was an outstanding speaker on a wide variety of subjects.

Resolved: That the board of directors of the American Institute of Electrical Engineers upon behalf of the membership expresses its keenest regret at the death of Doctor Wickenden and its highest appreciation of his inspiring leadership.

And be it further resolved that these resolutions be transmitted to members of his family.—*AIEE Board of Directors, November 5, 1947.*

Student Branch Conference Held by Middle Eastern District

A meeting of the District committee on Student activities for AIEE District 2 (Middle Eastern District) was held under the auspices of the AIEE Student Branch at the Case Institute of Technology, Cleveland, Ohio, on November 14 and 15, 1947. Members of this committee are the Student Branch chairmen and the counselor of each Student Branch in the District, plus the District vice-president and the District secretary. The meeting was open to all Student members and other AIEE members who wished to attend.

The conference opened on Friday, November 14, with a period for registration and inspection of the Case Institute of Technology campus. Each member who registered received an envelope containing an agenda for each of the three sessions to be held, as well as folders describing the inspection trip and other points of interest in Cleveland.

All arrangements for the meeting were made by the members of the Student Branch at the Case Institute of Technology, with the guidance of Doctor Paul L. Hoover (F'44) Student counselor, who was chairman of the 1946–47 District committee on Student activities.

CONFERENCE OF CHAIRMEN

The conference of Student Branch chairmen was held in the Institute's chemistry building, concurrently with the conference of counselors which met in the Case electrical engineering building on Friday morning. The following subjects were on the agenda for the conference of Student Branch chairmen:

1. Opening remarks by the chairman, R. W. Brisky (chairman of Case Student Branch).
2. How to get greater co-operation of the students in Branch activities.
3. Membership activity in the Branch.
4. District 2 Student Branch news sheet.
5. How to get greater co-operation by the Section and Section members in Branch activities.
6. (*a*). Why every Student member should join AIEE as an Associate member upon graduation.
    (*b*). How this transfer of membership should be accomplished.
    (*c*). The importance of the Institute keeping an accurate record of Student's address after graduation.
7. Branch prize paper competition starting January 1, 1948.

This conference-type meeting was attended by approximately 167 persons. Considerable time was devoted to each of the items on the agenda, and there was an interested and active discussion, the highlights of which were reported by a representative from the Student Branch to the joint student-counselor conference held Friday afternoon.

CONFERENCE OF COUNSELORS

At the conference of Student Branch counselors the following program was presented:

1. Opening remarks by the chairman, Doctor P. L. Hoover.
2. What constitutes a good counselor.
3. Discussion of Student Branch and District prize paper competition for Student members under the new Institute prize competition rules, which become effective January 1, 1948.
4. Membership activity.
5. Discussion of Section-Branch co-operation.
6. Other Branch activities.
7. Election of chairman for 1947–48 District committee on Student activities.
8. Organization of local engineering student councils in each school.
9. Relative merits of the various engineering societies and how this issue shall be met by AIEE.
10. The graduate student in AIEE.
11. How the smaller Branch can engage in all student activities.
12. Requirements for a new AIEE Branch.
13. Other items.

Each counselor present at the conference participated in the discussion, the highlights of which were reported by one of the counselors at the joint student-counselor conference. The total attendance was 27, 15 of whom were counselors.

During the course of the meeting, Professor J. L. Beaver (F'26) of Lehigh University was elected chairman of the 1947–48 District committee on Student activities and it was decided that the meeting of this committee next year would be held at Bethlehem, Pa. The committee also decided that the District Branch prize competition meeting would be held at Ohio State University, Columbus, Ohio, during April or May 1948.

JOINT CONFERENCE

After an informal luncheon, attended by 194 persons, at the Fenway Hall Hotel, a

A discussion of the program at the Middle Eastern District Student Branch conference brings together (left to right) District 2 Secretary A. C. Muir (M '39), G. W. Bower, AIEE Secretary H. H. Henline, and Professor Hoover

Student committee from the Case Institute of Technology, sponsor of the District 2 Student Branch Conference, includes (top row, left to right) P. H. Greenlee, W. Knox, E. Love, R. V. Bowen, Professor Hoover (counselor), and (bottom row, left to right) R C. Luthringer, R. W. Brisky, and H. E. Knowles

Student Branch counselors and chairmen of the Middle Eastern District meeting at the Case Institute of Technology

joint student-counselor conference was held on Friday afternoon in the auditorium of the Cleveland Engineering Society. The following topics were included in the agenda:

1. Opening remarks by chairman, Doctor P. L. Hoover.
2. Message from Professor J. F. Calvert (F '45) chairman, Institute committee on Student Branches.
3. Message from G. W. Bower (M '40), vice-president, District 2.
4. Student Branch and District prize paper competitions for Student members.
5. Plan of Section–Branch co-operation.
6. Membership activities.
7. How to get greater co-operation of the students in Branch activity.
8. How to get greater co-operation by the Section and Section members in Branch activity.
9. How the smaller Branch can engage in all student activities.
10. Transfer of Student members to Associates upon graduation.
11. District 2 Student Branch news sheet.

This was a "conference-type" meeting, with active participation by both the students and the counselors who made up the attendance of approximately 160. The meeting was followed by a period of recreation.

OTHER ACTIVITIES

On Friday evening, November 15, the Cleveland Engineering Society was host to an informal dinner at which 120 were present. Doctor T. Keith Glennan, president of the Case Institute of Technology, gave a short address of welcome. Following dinner, an entertaining talk on the subject of "Discomania" was presented by George C. A. Hantleman, secretary-manager of the Cleveland Engineering Society. As an interesting feature of his address, Mr. Hantleman played part of his collection of historical phonograph records and the audience was able to hear the voices of the late Guglielmo Marconi and Thomas A. Edison.

The 2-day conference was concluded on Saturday, November 15, with a 3-hour inspection trip to the General Electric Lighting Institute at Nela Park, Cleveland. This trip, as did all of the activities on the program, elicited a very gratifying response from the more than 200 registrants at the conference. The success of these meetings can be attributed in no small part to the active co-operation of the AIEE Cleveland Section with the Case Institute of Technology Student Branch and Professor Hoover, an excellent example of Section–Branch co-operation.

Pittsburgh Section Sponsors Power Station Visit

On October 14, 1947, the Pittsburgh Section of the AIEE sponsored an inspection trip to the Phillips power station of the Duquesne Light Company. More than 300 persons attended this very successful Section activity.

After the inspection trip, refreshments were provided for the group and they were served in the main generator turbine floor beside the 75,000-kva generator. Part of the large group that participated in this activity is shown elsewhere on this page, in the assembly room prior to the inspection trip through the plant.

Two short talks by Duquesne Light Company men were on the program: "The Operation of the Electric Equipment" by A. Hayward (A '30), and "The Operation of the Steam Equipment" by R. B. Donworth.

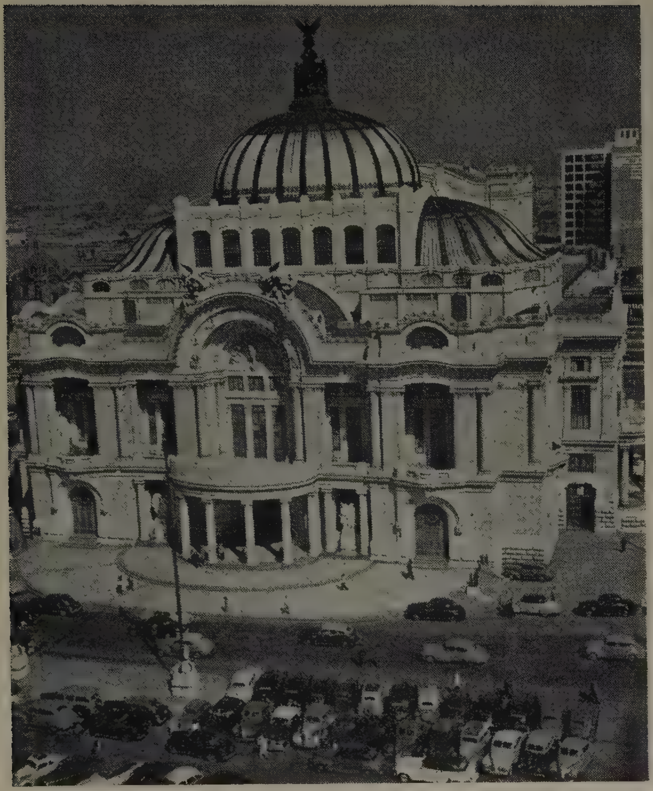
Plans are Progressing for Electron Tube Conference

Plans are coming along rapidly for an interesting and valuable program for the AIEE conference on electron tubes for instrumentation and industrial use to be held March 29–31, 1948, at Philadelphia, Pa. Headquarters will be in the Benjamin Franklin Hotel.

This AIEE-sponsored conference is open to all interested in low power electron tubes for instrumentation and industrial uses, and wide discussion is anticipated on the need for improvements and possible objectives. Further information, including a complete program, is scheduled for publication in the March issue of *ELECTRICAL ENGINEERING*.

Pittsburgh Section Inspection Trip

Part of a group of 300 who were present on an inspection trip sponsored by the AIEE Pittsburgh Section to the Frank R. Phillips power station of the Duquesne Light Company



Mexican Palace of Fine Arts

Activities running the gamut from ballet and symphony orchestras to presidential inaugurations are staged at the Palace of Fine Arts in the city of Mexico, Mexico, host city to the 1948 AIEE summer general meeting, June 21–25

Standards Prices Increased as Result of Rising Costs

As a result of present greatly increased printing costs, it has become necessary for the AIEE to raise the sale prices on all Standards publications as of January 1, 1948. The Institute postponed the action as long as possible, however, it has found the increase inevitable.

Members will continue to receive the usual discount of 50 per cent on single copies of Standards pamphlets with the exceptions which will be indicated clearly on the next new Standards order list to be issued as of January 1, 1948. The new price list appears in this issue on page 36A in the advertising section.

Fellowship Applicants Must File by February 15

Candidates for the Charles LeGeyt Fortescue Fellowships should file applications on the form provided by AIEE so that they reach the secretary of the fellowship committee by February 15. Awards will be made not later than April 1. Copies of the application forms are available at accredited colleges or at AIEE headquarters, 33 West 39th Street, New York 18, N. Y.

The Charles LeGeyt Fortescue Fellowship, sponsored by AIEE, was established in 1939 as a memorial to Charles Fortescue in recognition of his valuable contribution to the electric power industry. To this end the Westinghouse Electric Corporation, with which Doctor Fortescue was associated throughout his professional career, set up a trust fund of $25,000 to provide graduate fellowships in electrical engineering.

The successful candidates, selected by the AIEE committee which administers the fund, receive a minimum allowance of $500 and additional allowance may be granted at the discretion of the committee.

It is intended that candidates shall pursue their studies at accredited engineering schools and engage in research problems meeting the approval of the fellowship committee. To be eligible the student must have received a bachelor's degree from an accredited college by the time his work under the fellowship would begin, provided he does not hold or subsequently receive any other fellowship which carries a stipend greater than the tuition required by the institution at which the graduate work is to be undertaken.

PERSONAL • • • • •

A. B. Bronwell (A '34, M '44) professor of electrical engineering, Northwestern Technological Institute, Evanston, Ill., has assumed the post of secretary for the American Society for Engineering Education. Born on August 18, 1909, in Chicago, Ill., Professor Bronwell was graduated in 1933 with a bachelor of science degree in electrical engineering from the Illinois Institute of Technology. He received a master of science degree in 1936 from that institute and did additional graduate work at the University of Michigan in 1939 and 1940. He recently received a degree for work in business administration taken at Northwestern University. After graduating in 1933, Professor Bronwell was associated with the Commonwealth Edison Company, Chicago, until 1937 when he was appointed to the faculty of Northwestern University. In the summer of 1941 he was employed by the Bell Telephone Laboratories, New York, N. Y., as a special project engineer, and during the war he supervised radio and radar training at Northwestern University and served as a consultant to various manufacturing companies. Professor Bronwell served as a Student Branch counselor for the AIEE from 1938 to 1940 and was a member of the AIEE communications committee from 1939 to 1941. He is also a member of the American Society for Engineering Education, Institute of Radio Engineers, Sigma Xi, Eta Kappa Nu, and was president of the National Electronics Conference for 1947.

F. W. Bliss (A '30, M '45) district manager, advertising and sales promotion department, General Electric Company, Boston, Mass., for the past 19 years, has retired. He has been appointed a member of the Massachusetts Labor Relations Commission for a 5-year term, effective immediately. Born on May 13, 1883, in Cambridge, Mass., he received his technical education at the Westerleigh Collegiate Institute. In 1898 Mr. Bliss began the partnership of Bliss and Hinckley, contracting firm, in New York, N. Y. He dissolved that relationship in 1900 to become affiliated with the International Mercantile Marine Company, New York, N. Y. He was employed by the General Electric Company in 1905, and spent five years at the Edison Lamp Works, Harrison, N. J. In 1910 Mr. Bliss was transferred to the Providence, R. I., office as an industrial illuminating engineer, later becoming manager in charge of lamp sales in southeastern New England. In 1928 he was transfered to the Boston office where he was advanced to the position which he held at the time of his retirement. Mr. Bliss was president of the Engineering Societies of New England, Inc., for three terms, and he is a past president of the Providence Engineering Society. He is also a former trustee of the Electric Lighting Institute of Brown University.

Arthur Raynsford (A '08) member of the technical staff, telephone systems development, Bell Telephone Laboratories, Inc., New York, N. Y., has retired. Born on October 30, 1882, in Greece, N. Y., Mr. Raynsford received a bachelor of arts degree in 1905 from the University of Rochester. He then became affiliated with the Western Electric Company as a member of the special student course and in 1906 was made an assistant in the cable department. In 1908 he began working in the engineering inspection department, transferring to the equipment engineering department in 1909. Since 1915, when Mr. Raynsford became associated with the circuit laboratory of the company, he has been engaged in the development of the panel and crossbar systems.

J. S. Riddile (A '07, F '21) operation department, Shawinigan Water and Power Company, Montreal, Quebec, Canada, has retired. Born in Barnesville, Ohio, on February 3, 1883, he was graduated in 1904 from Ohio State University with the degree of mechanical engineer in electrical engineering. From 1904 to 1905 Mr. Riddile was a fellow in the department of electrical engineering, Ohio State University, Columbus, leaving at that time to join the East Pittsburgh (Pa.) Works of the Westinghouse Electric and Manufacturing Company as an engineering apprentice. He joined Ralph D. Mershon in New York, N. Y., in 1906 where he was engaged in varied engineering work of a commercial and research nature. Mr. Riddile then was with the Laurentide Power Company, Ltd., Grand Mere, Quebec, from 1915 to 1929, as manager of power. He became associated with the Shawinigan Power Company in 1929 in the capacity of executive engineer and has been with the concern since that time. Mr. Riddile is also a member of the American Association for the Advancement of Science and of Sigma Xi.

L. W. Long (A '37, M '44) formerly sales engineer-in-charge, mixed apparatus sales, electrical department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been promoted to the position of manager of the substation section (formerly known as the mixed apparatus section). Mr. Long has been with the Allis-Chalmers Company for more than 20 years. Other promotions with that organization include **R. M. Casper** (M '40) formerly sales engineer-in-charge of sales, motor and generator division, electrical department, now advanced to become manager of the firm's motor and generator section, and **G. W. Clothier** (A '36, M '42) formerly engineer-in-charge of transformer sales, electrical department, named manager of the transformer section. Both men joined the company in 1936. Announcement also has been made of the appointment of **C. W. Bernhard** (A '45) formerly assistant sales engineer in charge of motors and generators sales for the firm, as assistant to Mr. Casper. Mr. Bernhard has been with the Allis-Chalmers Company since 1928.

C. T. Sinclair

C. T. Sinclair (A '19, F '36) formerly chief engineer, engineering and construction department, Duquesne Light Company, Pittsburgh, Pa., has been appointed chief engineer in charge of engineering and construction with that company. A native of Baltimore, Md., Mr. Sinclair was graduated from Lehigh University in 1917, with an electrical engineering degree. He entered the employ of the Duquesne Light Company in 1925 as supervisor of transmission and distribution engineering. Mr. Sinclair is a past vice-president of AIEE, a member of the Pennsylvania Electric Association, American Standards Association, Edison Electric Institute, and of the Association of Edison Illuminating Companies.

C. W. Franklin (M '24, F '44) electrical engineer, the Consolidated Edison Company of New York (N. Y.) Inc., was one of two delegates of the American World Power Committee attending the World Power Conference held in The Hague, Netherlands, last September. **J. C. Parker** (A '04, F '12) vice-president of the Consolidated Edison Company of New York (N. Y.) Inc., and AIEE president for the 1938–39 term, was a member of the executive committee of the United States National Committee during that conference, and **W. F. Davidson** (A '14, F '26) research engineer, and director of research, Consolidated Edison Company of New York (N. Y.) Inc., presented a paper on nuclear energy for power production at the meeting. **M. J. Steinberg, Jr.** (A '24, M '32) division engineer, system engineering department, Consolidated Edison Company of New York (N. Y.) Inc., in collaboration with Mr. Davidson, presented a paper on combined steam and electric supply in New York.

G. B. Thomas (A '10, M '16) retired personnel director, Bell Telephone Laboratories, New York, N. Y., has been appointed to the newly created position in that organization of chief of the department of industrial relations, Los Alamos (N. Mex.) scientific laboratory. Born in Portage County, Ohio, in 1882, Mr. Thomas was graduated from Ohio State University with the degree of mechanical engineer in electrical engineering in 1907. From 1907 to 1910 he was an assistant and an instructor in the electrical engineering department at the Massachusetts Institute of Technology, Cambridge, accepting a position in 1910 in the electrical engineering department of Colorado College, Colorado Springs, where he also served as acting dean from 1914 to 1915. Mr. Thomas became associated with the Western Electric Company, New York, N. Y., in 1917, working in the submarine detection section of the engineering department. In 1918 he was made director of technical training in the engineering department of that company, and he was appointed personnel director for the Bell Telephone Laboratories in 1925, a position from which he retired in the latter part of 1947. Mr. Thomas has served on the AIEE education committee for 14 years. He also has been active in the American Society for Engineering Education, the Engineers' Council for Professional Development, the American Management Association and the Ohio University Society of New York.

A. W. Melloh (A '38, M '45) formerly senior telephone engineer, Stromberg-Carlson Company, Rochester, N. Y., has been appointed vice-director of the Texas engineering experiment station at the Agricultural and Mechanical College of Texas, College Station. Doctor Melloh had been associated with the Stromberg-Carlson Company since 1945, having been with the University of California, division of war research, at the United States Navy Radio and Sound Laboratory, San Diego, Calif., prior to that time.

N. E. Wilson (A '38, M '46) formerly associated with the Commonwealth and Southern Corporation, Jackson, Mich., has joined the staff of the electrical engineering department of the University of Massachusetts, Amherst, as an associate professor. Mr. Wilson received a bachelor of science degree in electrical engineering from Cornell University in 1937 and a master of science degree in electrical engineering from the Illinois Institute of Technology in 1947.

J. J. Bartolotta (A '46) formerly assistant research engineer, McDonnell Aircraft Corporation, St. Louis, Mo., has joined the electrical design section of George E. Wells, Inc., St. Louis, consulting engineers and product designers. Mr. Bartolotta received an electrical engineering degree from Washington University in 1942.

C. H. LeVee (M '42) formerly affiliated with the Fagan Electric Company, Little Rock, Ark., has been appointed manager of electric utility sales, wire and cable department, United States Rubber Company. Mr. LeVee will have his headquarters in the company's general offices in New York, N. Y., and he will be responsible for the sale of wire and cable to electric light and power companies.

J. L. Sanders, Jr. (A '45) formerly division sales supervisor, Florida Power and Light Company, Sarasota, has joined the Langley

Memorial Aeronautical Laboratory, National Advisory Commission for Aeronautics, Langley Field, Va., in the capacity of an aeronautical engineer.

F. H. Craton (A '31, M '38) former assistant manager of the transportation division, General Electric Company, Erie, Pa., has been promoted to manager of sales for that division. Mr. Craton has been connected with the General Electric Company since 1924 when he joined that concern's factory management course in Schenectady, N. Y.

P. J. Croft (M '43) formerly transmission and distribution engineer, the Canada Wire and Cable Company, Ltd., Toronto, Ontario, has been named a district engineer for that concern. His office will be located in Montreal, Quebec, and he will serve eastern Canada. Mr. Croft joined the Canada Wire and Cable Company in 1945.

R. B. Colton (F '46) major general, United States Army (retired) recently was elected a vice-president of the Federal Telephone and Radio Corporation, Clifton, N. J., a domestic manufacturing affiliate of the International Telephone and Telegraph Corporation. General Colton was graduated from Yale University in 1908, and received the degree of master of science from the Massachusetts Institute of Technology in 1920. He was commissioned a second lieutenant in the Coast Artillery Corps of the regular Army in 1910 and transferred to the Signal Corps in 1930 with the rank of lieutenant colonel. After graduation from the Army War College in 1938, General Colton served as director of the Signal Corps Laboratories at Fort Monmouth, N. J. He retired in 1946, after more than 30 years of service with the Army, to enter private business.

O. E. Buckley (M '19, F '29) president, Bell Telephone Laboratories, Inc., New York, N. Y., and a vice-president of the AIEE for the 1946–47 term, was one of the 7-member Industrial Advisory Board of Consultants recently designated to advise the United States Atomic Energy Commission on the speeding up of industrial opportunities in the atomic energy field.

E. J. Januszko (A '45) formerly a Detroit, Mich., representative of Kelite Products, Inc., of Illinois, is now a Detroit representative for the DuBois Company of Cincinnati, Ohio.

H. R. Anderson (A '27, M '36) formerly system development engineer for the Bonneville Power Administration, Portland, Oreg., has been appointed a power system engineer for the Camp Le Jeune–Cherry Point (N. C.) Electric Power System, with headquarters at Camp Le Jeune, by the United States Navy. A graduate in electrical engineering of Iowa State College, Mr. Anderson joined the Bonneville Power Administration in 1939.

H. M. Patterson (A '37, M '40) formerly an electrical engineer, Decatur, Ga., has announced the formation of an engineering partnership in Decatur to be known as Patterson and Dewar. Mr. Patterson has been engaged in system studies for rural and city electric distribution systems.

D. B. Hoseason (A '22, M '28) director of studies at the Administrative Staff College, Henley-on-Thames, England, has been elected a member of the General Council of the Engineers' Guild.

J. M. Comly (A '26, M '36) affiliated with the Consolidated Edison Company of New York (N. Y.) Inc., is serving as third vice-chairman of the executive committee of the New York Engineers' Committee on Student Guidance. **B. G. A. Skrotzki** (M '45) assistant editor of the magazine, *Power*, McGraw-Hill Publishing Company, Inc., New York, N. Y., is serving as secretary for that committee, and **S. P. Shackelton** (A '18, M '23) apparatus development department, Bell Telephone Laboratories, Inc., New York, N. Y., is chairman of the AIEE subcommittee for the organization.

H. V. Bozell (A '08, F '23) president, General Telephone Corporation, New York, N. Y., recently was elected second vice-president of the United States Independent Telephone Association. **L. W. Hill** (M '31) president, Carolina Telegraph and Telephone Company, Tarboro, N. C., was one of three new executive committee members elected by the association.

C. E. Arvidson (A '37, M '39) formerly supervisor of the investigations section of the general engineering department, Consumers Power Company, Jackson, Mich., has been named supervisor of the electric construction department recently formed by that concern.

H. J. Scholz (A '21, F '46) formerly supervising engineer, Commonwealth and Southern Corporation, Birmingham, Ala., has been named a vice-president of that concern. The announcement was made by the Commonwealth and Southern Corporation of New York, the service company for the Commonwealth and Southern Corporation system. Mr. Scholz has been associated with that organization since 1931.

F. F. Brand (A '10, F '39) former works engineer of the Pittsfield section of General Electric Company, has been named manager of engineering for that organization. Mr. Brand was graduated from City Guilds of London Engineering College in 1902 as an electrical engineer. He joined the Pittsfield Works of the General Electric Company in 1906, and since 1913 has been associated predominantly with various phases of transformer work. **H. F. McRell** (A '25) formerly manager of the old transformer division has been advanced to the position of manager of sales with the Pittsfield section of the General Electric Company. He joined the company in 1910 and has been concerned mainly with activities of the transformer division since that time.

E. J. Warchol (A '43) ensign, United States Naval Reserve, has been relieved of active duty and now is employed as an electrical engineer at the Puget Sound Navy Yard, Bremerton, Wash. Before enlisting in the United States Navy, Mr. Warchol was with the General Electric Company, Schenectady, N. Y.

W. S. Ginn (A '37) formerly power transformer sales engineer, the General Electric Company, Pittsfield, Mass., has been appointed assistant manager of sales in the power transformer section of the transformer division, Pittsfield apparatus works.

R. M. Darrin (A '28, M '34) formerly assistant district manager of central station divisions, the General Electric Company, New York, N. Y., has been appointed manager of the central station divisions. Mr. Darrin has been associated with the General Electric Company since 1919.

M. F. Beebe (A '41) formerly general superintendent of production, United Illuminating Company, New Haven, Conn., has been appointed superintendent of operations in charge of the company's production and distribution departments. Mr. Beebe has been associated with that concern since 1916. **P. V. Plummer** (A '33, M '44) formerly assistant to the general superintendent of production, United Illuminating Company, New Haven, Conn., has been named to succeed Mr. Beebe as superintendent of production.

L. H. Poe (M '38) formerly superintendent, electric department, Central Arizona Light and Power Company, Phoenix, Ariz., has been appointed manager of that concern's newly organized central division which covers gas and electric service in the Phoenix metropolitan and suburban areas. Mr. Poe also will serve as district manager for Phoenix. He joined the company in 1941.

J. F. Gogins (A '40) northwestern district manager, industrial division, apparatus department, General Electric Company, Portland, Oreg., in addition has been named manager of that company's apparatus department in Portland. He thus will be responsible for all apparatus department activities in Oregon and southwestern Washington.

E. H. Smith (A '43) formerly affiliated with the Boeing Aircraft Company, Seattle, Wash., recently was appointed a research associate on the college of engineering faculty at the University of Washington, Seattle. **H. M. Swarm** (A '41) formerly associate electronics engineer, applied physics laboratory, University of Washington, has been named an instructor in the college of engineering at that institution

V. E. Goodwin (A '07, M '37) managing engineer, lightning arrester, cutout and capacitor department, the General Electric Company, Pittsfield, Mass., has retired after 43 years of service with that company. Mr. Goodwin joined the test section of the General Electric Company, Schenectady, N. Y., after graduating from the University of Minnesota in 1904 with a bachelor of science degree in electrical engineering. He was in charge of the lightning arrester engineering division when it was transferred from Schenectady to Pittsfield in 1913. He was made managing engineer of the lightning arrester, cutout and capacitor divisions in 1930, and has served in that capacity until his retirement. Mr. Goodwin is a past chairman of the Pittsfield (Mass.) Section of the AIEE.

H. H. Scott (A '32, M '38) formerly president of the Technology Instrument Corporation, Waltham, Mass., has announced his resignation as an officer of that company, and the formation of a new organization in Cambridge, Mass., to be known as Hermon Hosmer Scott, Inc., of which he will be president and director of engineering. **R. P. Glover** (M '45) consulting engineer, Oak Park, Ill., will act as Midwestern engineering representative for this concern.

H. L. Bradley (A '15, M '45) executive vice-president, Allen—Bradley Company, Milwaukee, Wis., has been named chairman of the board of directors for that concern.

J. A. Tyvand (M '37, F '45) formerly chief electrical engineer, Parsons, Brinckerhoff, Hogan, and McDonald, consulting firm, New York, N. Y., has joined the Otter Tail Power Company, Fergus Falls, Minn., as system planning engineer.

D. D. Smalley (A '20, M '33) formerly engineer of electric operation, Pacific Gas and Electric Company, San Francisco, Calif., has taken office as vice-president in charge of the company's operations. **G. H. Hagar** (A '20, M '26) formerly assistant engineer of operation with the same company has succeeded Mr. Smalley as engineer of electric operation. **H. G. Keesling** (A '19) formerly electrical superintendent of the company's East Bay division (Oakland, Calif.) has been appointed central area superintendent, replacing Mr. Hagar.

R. E. Forman (A '40) formerly chief design engineer, Pacific Power and Light Company, Portland, Oreg., has been appointed to a new post as superintendent of distribution. **A. O. Mangold** (A '37) formerly associated with the Northwestern Electric Company, Vancouver, Wash., as a result of that company's merger with the Pacific Power and Light Company has been named division engineer for the latter organization.

H. V. Rathbun (A '29, M '37) previously associated with the Copperweld Steel Company, Glassport, Pa., as their Midwestern representative, has been appointed transmission and distribution engineer for the Western Light and Telephone Company, Kansas City, Kans.

K. B. Hoffman (A '34, M '41) assistant engineer, inside plant bureau, Consolidated Edison Company of New York (N. Y.) Inc., since 1930, has resigned from that position. He now is associated with the firm, Burns and Roe, Inc., New York, N. Y., as an electrical engineer.

R. E. Uptegraff, Jr. (A '39) sales manager, R. E. Uptegraff Manufacturing Company, Scottdale, Pa., recently was awarded a naval citation for his research and development in naval ordnance, particularly in torpedo proximity exploder mechanisms. During the war Mr. Uptegraff participated in naval ordnance activities on the Pacific Coast.

P. R. Watson (A '37, M '45) formerly head of the electrical laboratory, McDonnell Aircraft Corporation, St. Louis, Mo., has been named sales manager for George E. Wells, Inc., St. Louis. Mr. Watson served as assistant materials and processes engineer for Curtiss-Wright Corporation, St. Louis, during the war. He is a 1936 graduate of the University of Missouri.

L. H. Hill (A '22, F '38) publisher of *Electrical World* since 1945, resigned on October 1, 1947, to return to industry. With his resignation several changes have taken place on the staff of this magazine. **G. C. Tenney** (A '35, M '42) vice-president of McGraw-Hill Publishing Company and publisher-editor of *Electrical West*, San Francisco, Calif., also has been named acting editor of *Electrical World*. Mr. Tenney joined the staff of *Electrical West* after graduating from the University of California in 1920, and he has been editor of the magazine since 1930. He is a past president of the Pacific Coast Electrical Association, and he has been chairman of the San Francisco section of the AIEE. **A. E. Knowlton** (M '17, F '30) associate editor of *Electrical World* since 1930, has been advanced to the position of senior associate editor, and **D. T. Braymer** (A '42) formerly western editor, Chicago, Ill., for the magazine, has been named associate editor.

R. L. Schacht (A '44) formerly superintendent of transmission and distribution, Consumers Public Power District Eight, Lincoln, Neb., has been made general operating superintendent for that concern.

T. C. Wright (A '28, M '46) president of the Otter Tail Power Company, Fergus Falls, Minn., recently was elected president of the North Central Electric Association.

H. C. Cummins (M '44) vice-president in charge of operations, Northern States Power Company, Minneapolis, Minn., also has been named first vice-president of the company. Mr. Cummins has been with the Northern States Power Company from 1911 to 1917 and from 1939 to the present.

H. J. Woll (A '42) advanced development engineer, RCA Victor Division, Radio Corporation of America, Camden, N. J., is the first RCA Victor employee to be awarded an RCA fellowship under a new graduate plan established by the board of directors of that corporation. Under this plan Mr. Woll will devote the 1947–48 academic year to graduate studies at the University of Pennsylvania, working toward a doctor of philosophy degree.

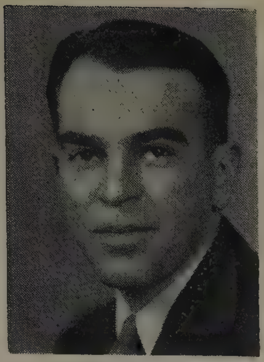
V. K. Zworykin (M '22, F '25) associate research director, RCA Laboratories, Radio Corporation of America, Princeton, N. J., left New York recently to attend engineering conferences in Belgium, France and Italy. While in Europe, Doctor Zworykin will visit technical laboratories in England, Holland, and Switzerland.

C. G. Howard (A '28, M '36) manufacturers representative, Chicago, Ill., has been appointed sales representative in the Chicago area by Mines Equipment Company, St. Louis, Mo. Mr. Howard will be concerned with the sale of electric connectors and cables in the railway and industrial fields.

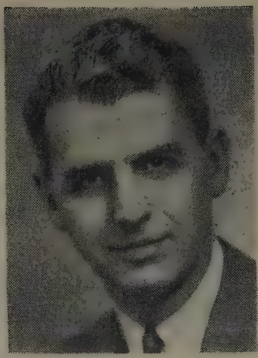
W. F. McMullen (A '45) formerly a lieutenant colonel in the Royal Canadian Artillery, recently joined the staff of the Canadian Electrical Manufacturers Association, Toronto, Ontario. He will hold the position of commercial assistant to the general manager.

M. A. Thomas (A '31, M '39) previously professor and head of the electrical engineering department, New Mexico College of Agriculture and Mechanic Arts, State College, has been appointed dean of the school of engineering at that institution. He has been affiliated with the New Mexico College of Agriculture and Mechanic Arts since 1931.

H. A. Glover



E. C. Thompson



H. N. Muller, Jr.

H. A. Glover (A '39) previously sales department supervisor, S and C Electric Company (formerly Schweitzer and Conrad, Inc.), Chicago, Ill., has been appointed assistant sales manager of that concern. Mr. Glover, a 1932 graduate of the Carnegie Institute of Technology, joined the S and C Electric Company in the fall of 1946 after serving in the United States Navy for three years.

L. H. Johnson (M '20) systems development department, Bell Telephone Laboratories, Inc., New York, N. Y., has retired after 38 years of service with that company. After graduating from the Massachusetts Institute of Technology in 1909 with a bachelor of science degree, Mr. Johnson joined the student course of the Western Electric Company, Hawthorne, N. Y., transferring to the Bell Telephone Company's circuit laboratory in 1910. He was in charge of local signaling development from early 1946 until June 1947, and since then he has been engaged in consultation work.

F. J. Singer (A '36, M '38) switching development engineer, Bell Telephone Laboratories, Inc., New York, N. Y., has been selected first vice-president of the Bell Laboratories Club for 1947–48.

J. L. Balleny (M '47) formerly manager, of the industrial heating section of the Canadian General Electric Company's head office in Toronto, Ontario, has been appointed manager of that concern's Trail, British Columbia, office. He began the duties of his new position on September 1.

E. M. Williams (A '40) associate professor of electrical engineering at the Carnegie Institute of Technology, Pittsburgh, Pa., was awarded the President's Certificate of Merit for "outstanding fidelity and meritorious conduct in aid of the war effort . . . in World War II" recently.

H. M. Bascom (M '19, F '30) director of switching engineering, Bell Telephone Laboratories, New York, N. Y.; **C. O. Bickelhaupt** (M '22, F '28) vice-president, the American Telephone and Telegraph Company, New York, N. Y.; and **J. B. Rees** (M '31, F '32) assistant vice-president, the American Telephone and Telegraph Company, New York, N. Y.; were among the four men who, in recognition of their war service in developing signal equipment and operating methods, were awarded certificates of appreciation by the War Department.

E. C. Thompson (A '38) formerly assistant manager, power utilities department, Ohio Brass Company, Mansfield, has been named district manager of the Texas territory for that company. His headquarters for the district will be in Dallas. Mr. Thompson joined the concern in 1937 as a sales engineer.

H. N. Muller, Jr. (A '37, M '43) formerly manager, graduate student training, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been promoted to educational department manager with that company. In his new position, Mr. Muller will supervise both the university relations and graduate student training programs. He has been affiliated with the corporation since 1935.

J. F. Harrison (M '40) formerly general superintendent, operating and engineering department, the Mississippi Power and Light Company, Jackson, Miss., has been promoted to the position of engineering consultant as a result of recent personnel changes in that company. **J. B. Fountain** (A '35) formerly engineering superintendent in charge of all electrical and civil engineering functions, has been appointed chief engineer, and **R. W. Braswell** (M' 43) formerly operating superintendent for that company, has been named operating and engineering manager.

E. D. Johnson (M '28) electrical engineer, Bell Telephone Laboratories, Inc., New York, N. Y., has retired after 41 years of service with that company. He joined the Bell System after graduate work at the Sheffield Scientific School of Yale University from which he had received a bachelor of philosophy degree previously. Mr. Johnson was engaged in studies for the switching development department from 1935 to 1942, and since that time has been active in military relations personnel work. He has been associated with many important telephone projects, both in the United States and abroad.

E. A. Miller (A '45) formerly chief engineer, Acme Electric Corporation, Cuba, N. Y., has been elected vice-president, in charge of engineering, for that company. Mr. Miller joined the Acme organization in 1930.

E. G. Keller (M '40) formerly chief research engineer, Curtiss-Wright Corporation, Buffalo, N. Y., has resigned from that position to rejoin the General Electric Company in Schenectady, N. Y.

W. E. Tinsley (A '44) formerly engineer, Servo Corporation of America, now is affiliated with the pilotless plane division of the Fairchild Engine and Airplane Corporation at Farmingdale, N. Y. He holds the position of electronics engineer with that firm.

F. H. Streit (A '30) formerly chief design engineer, the Columbus and Southern Ohio Electric Company, Columbus, recently was appointed chief engineer with that company. Mr. Streit has been associated with that firm for the past year.

C. D. Grady (A '37) formerly construction engineer, Union Electric Company, St. Louis, Mo., has been appointed assistant superintendent, electrical department, with that company. Mr. Grady has been with that concern since 1921.

L. W. Whitton (A '40) production manager, Otis Elevator Company, New York, N. Y., has been elected vice-president of that company, and now will serve in both positions.

G. E. Johnson (A '13, M '37) chief engineer and general manager, Central Nebraska (Tri-County) Public Power and Irrigation District, Hastings, has resigned. Mr. Johnson has been general manager for 13 years, and had charge of the construction of the $38,000,000 Tri-County project.

H. M. Hess (A '35, M '46) associate professor of electrical engineering, Wayne University, Detroit, Mich., has been named to serve as vice-chairman of the Engineering Society of Detroit for the remainder of the current fiscal year ending June 30, 1948.

H. W. Smith (M '29) formerly protection engineer, British Columbia Electric Railway Company, Ltd., Vancouver, Canada, has been appointed assistant chief engineer of the engineering division of that company. Mr. Smith has been connected with that concern for two years. **C. G. Mills** (A '28) formerly protection and communications engineer, British Columbia Electric Railway Company, Ltd., Vancouver, has been appointed to the position vacated by Mr. Smith.

A. E. Fleming (A '46) manager, supply sales division, General Electric Supply Company, Salt Lake City, Utah, has been re-elected chairman of the Utah chapter, Illuminating Engineering Society, for the fiscal year beginning October 1.

W. L. Shaw (A '45) industrial sales manager, Utah Power and Light Company, Salt Lake City, was named secretary-treasurer of the society, and **J. V. Sharp,** (A '38) owner and manager, Sharp Electric Company, Salt Lake City, was named to the board of managers.

K. R. Van Tassel (A '27) formerly manager, industrial control division, apparatus department, General Electric Company, Schenectady, N. Y., has been named one of 15 unit managers as a result of General Electric Company's new form of management of the apparatus department in an effort to provide for expanded production. Mr. Van Tassel will be in charge of the control divisions unit at the company's Schenectady plant. Other unit managers named include: **N. M. DuChemin** (A '29) formerly manager, West Lynn (Mass.) Works, General Electric Company, now appointed manager of the West Lynn Works, meter and instrument divisions; **Robert Paxton** (A '26, M '40) formerly associated with the General Electric Company, Pittsfield, Mass., now named manager of the transformer and allied product divisions of the Pittsfield plant; and **R. F. Tinnerholm** (A '30, M '45) formerly manager, switchgear division, central station division, General Electric Company, Philadelphia, Pa., now made manager of the switchgear divisions of that same plant.

J. W. Asmann (A '32) formerly senior operating engineer, Cincinnati (Ohio) Gas and Electric Company, has been appointed assistant superintendent of electric operating with that organization. He joined the company in substation maintenance work in 1927, and was made operating engineer in 1939.

A. W. Robertson (A '27) chairman of the board of directors of the Westinghouse Electric Corporation, Pittsburgh, Pa., has been awarded the President's Certificate of Merit for services in behalf of the Navy's wartime shipbuilding program.

C. O. Bickelhaupt (M '22, F '28) vice-president of the American Telephone and Telegraph Company, New York, N. Y., was the commencement speaker for the graduating class of the South Dakota School of Mines and Technology, Rapid City. During the exercises Mr. Bickelhaupt received the honorary degree of doctor of engineering.

G. D. Edwards (A '16, M '26) director of quality assurance, Bell Telephone Laboratories, Inc., New York, N. Y., was presented with a certificate of appreciation by the War Department "for loyal and outstanding assistance to the Ordnance Department during World War II in the application of quality control to quantity production of ordnance matériel."

R. S. Plotz (A '38, M '45) formerly assistant to vice-president, Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed systems staff engineer for that concern, and **Albert Tradup** (M '36) formerly privatet branch exchange engineer, Bell Telephone Laboratories, Inc., has been transferred to the specialty products development department as military communications engineer.

Harvey Fletcher (M '23, F '30) director of physical research, Bell Telephone Laboratories, Inc., New York, N. Y., served as chairman of the acoustic meeting of the Society of Motion Picture Engineers' Theater Engineering Conference which was held in New York, N. Y., recently.

C. R. Kingsbury (M '39) district manager, Ohio Brass Company, Seattle, Wash., has been named first vice-president of the Electric Club of Washington at the state-wide electrical organization's meeting held recently.

L. F. Hunt (A '21, F '38) chief electrical engineer, operations department, Southern California Edison Company, Ltd., Los Angeles, has been appointed one of the United States representatives to the Biennial International Conference on Large Electric High-Tension Systems (CIGRE) to be held in Paris in 1948. As a member of the high-tension switching, circuit breakers, and relaying committee, Mr. Hunt will appoint the United States advisory members for his committee and will aid in the contribution of technical papers on the general subject of switching and relaying. He is well known for his highly important electrical developments, and in 1940 he was the recipient of the national "Modern Pioneer" award for his contributions toward increasing the quality of electrical utility service.

R. E. Shelby (A '36, M '44) formerly development engineer, National Broadcasting Company, Inc., New York, N. Y., has been appointed to the post of director of television engineering operations with that concern. **G. M. Nixon** (A '28, M '38) formerly assistant development engineer, engineering department, National Broadcasting Company, Inc., New York, N. Y., has been appointed to fill the position of development engineer.

C. E. Dean (A '23, M '37) director of publications, Hazeltine Electronics Corporation, Bayside, N. Y., was awarded a certificate of commendation by the United States Navy recently for his part in the writing and producing of technical instruction books required for radio equipment designed by the firm.

H. C. Frost (A '35) assistant director of engineering, chemical division, Corn Products Refining Company, Argo, Ill., has been elected a vice-president of the Instrument Society of America for the year 1947–48.

M. W. Scheldorf (A '38, M '45) formerly associated with the General Electric Company, Syracuse, N. Y., recently joined the Andrew Company, Chicago, Ill., as head of engineering research. He will be in charge of the development of new antennas, transmission lines, and other related items.

OBITUARY • • • • •

Cummings C. Chesney (A '94, M '99, F '13) honorary vice-president, General Electric Company, Pittsfield, Mass., died on November 27, 1947. Mr. Chesney was president of the AIEE in 1926–27, and Edison Medalist in 1921. Born in Selingsgrove, Pa., on October 28, 1863, he was graduated from Pennsylvania State College in 1885 with a bachelor of science degree. In 1885–86 Mr. Chesney was an assistant chemist in the chemical laboratory of the Pennsylvania State College, State College, and in 1887 he accepted a position as a chemist and professor of mathematics at the Doylestown (Pa.) Seminary. The following year he joined William Stanley's laboratory staff at Great Barrington, Mass., and in 1889 was employed by the United States Electric Lighting Company, Newark, N. J., as an electrical engineer. He became a member of the Stanley Laboratory Company, Pittsfield, Mass., in 1890, serving as supervising and designing electrical engineer. When the Stanley Electric Manufacturing Company was incorporated in 1893, Mr. Chesney was one of the incorporators and he became vice-president and chief engineer for that concern. The company was absorbed by the General Electric Company in 1907, and Mr. Chesney was named manager and chief engineer of the Pittsfield Works. In 1927 he was appointed vice-president of the General Electric Company, in charge of manufacturing at all of its plants. He retired on December 30, 1930, with the title of honorary vice-president. Mr. Chesney served on the AIEE Edison Medal committee from 1914 to 1919 and from 1923 to 1928; the executive committee from 1926 to 1929; the Institute policy committee from 1928 to 1935; and the Lamme Medal committee from 1929 to 1932, of which he served as chairman for the 1931–32 term. He represented the AIEE on the now defunct American Engineering Council from 1927 to 1929; the Charles A. Coffin Fellowship and Research Fund Committee in 1926–27; the John Fritz Medal Board of Award from 1926 to 1930; and the United States National Committee of the International Electrotechnical Commission in 1926–27. Mr. Chesney was a director of the Boston and Albany Railroad, the Massachusetts Mutual Life Insurance Company, and the Agricultural National Bank at Pittsfield. He was a member of the American Institute for the Advancement of Science, the Society of Arts and Sciences, London, and the Union League Club of New York.

John Henry Pilkington (A '26, M '34) assistant to the purchasing agent, the Consolidated Edison Company of New York (N. Y.) Inc., died on November 10, 1947. Born in Highmore, S. Dak., on February 20, 1898, Mr. Pilkington was graduated from the University of Michigan in 1922 with a bachelor of science degree in electrical engineering. He joined the student engineering course sponsored by the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation) in 1922, and was appointed design engineer for that organization in 1923. From the later part of 1923 to 1926 Mr. Pilkington was employed by the Brooklyn (N. Y.) Edison Company, Inc., first as a technical assistant and then as an assistant engineer in the outside plant engineering section. He was promoted to assistant supervisor of the cable bureau of the purchasing department in 1926, advanced to departmental assistant for that department in 1928, and made division engineer of the sales department of that organization in 1933. Mr. Pilkington transferred to the Consolidated Edison Company of New York, Inc., as manager of the technical bureau in the technical development and research department in 1936. Later he was assigned to the system engineering department, and in 1946 was promoted to the position which he held at the time of his death. Mr. Pilkington served on the AIEE membership committee from 1939 to 1944, and was chairman of that committee from 1942 to 1944. He was named chairman of the New York Section for the year 1946–47 and had been named to serve on the AIEE Sections committee for 1947–48.

Sir Standen Leonard Pearce (A '08, M '09, F '12) engineer-in-chief and a director, London (England) Power Company, Ltd., died recently. Born on September 28, 1873, at "Crewkerne," Somerset, England, Sir Leonard was educated at the Bishop's Stortford College and Finsbury Technical College. He served his apprenticeship with the Electrical Engineering Company, West Drayton, Middlesex, from 1891 to 1892, and with Thomas Richardsons Ltd., Hartlepool, Durham, from 1892 to 1895. Sir Leonard held the position of assistant engineer with the British India Steam Navigation Company, Ltd., Calcutta, India, from 1895 to 1897, when he accepted a position with the Metropolitan Electric Supply Company, London. In 1899 he was associated with the British Thomson-Houston Company, and in 1900 was named superintendent engineer with the Central London Railway. He was appointed deputy chief electrical engineer for the Manchester Corporation in 1901 and promoted to chief electrical engineer for that organization in 1904. Sir Leonard held that position until 1925 when he was named an electricity commissioner. In the following year he joined the London Power Company as engineer-in-chief. He was made a Commander (of the Order) of the British Empire in 1919 and received his knighthood in 1935. Sir Leonard became a member of the Institution of Electrical Engineers in 1904, served as a member of its council, and was vice-president in 1920. In January, 1947, he was awarded the Faraday Medal in recognition of his services to electrical engineering. He was also a past president of the Manchester, England, Section of the Institution of Civil Engineers, the Incorporated Municipal Electrical Association, and the Junior Institution of Engineers.

Ezra Frederick Scattergood (A '08, M '10, F '13) advisory engineer, Department of Water and Power, City of Los Angeles, Calif., died on November 15, 1947. Born near Burlington, N. J., on April 9, 1871, he was graduated from Rutgers College in 1893 with a bachelor of science degree. Mr. Scattergood was a draftsman and assistant to the manager, United Electric Improvement Company of Philadelphia, Pa., from 1893 to 1895, when he accepted a position as an instructor in mathematics and electricity in Rutgers College, New Brunswick, N. J. He received his master of science degree from Rutgers in 1896, and in 1898 was named a fellow in electrical engineering, Sibley College, Cornell University, where he was awarded a master of mechanical engineering degree in 1899. He was appointed a professor of physics and electrical engineering at the Georgia School of Technology, Atlanta, in 1899, and later was made professor of physics and experimental engineering, thus becoming a full professor in charge of the two departments. He resigned from that position in 1901 because of ill health, and went to New Mexico where for six months he was in charge of a field party for the Southern Pacific Company. During 1902–06 Mr. Scattergood was employed in the common electrical engineering offices of the Pacific Light and Power Company, the Pacific Electric Railway Company, and the Los Angeles Railway Company, all located in Los Angeles, Calif. From 1906 to 1909 he served as a consulting electrical engineer with offices in Los Angeles, and in 1909 was appointed chief electrical engineer, City of Los Angeles, Bureau of Los Angeles Aqueduct Power. He was made electrical engineer, City of Los Angeles, Department of Public Service, in 1911, and retained that appointment until 1940, when he retired and was named a consultant to the power division of that municipal utility. Mr. Scattergood was an authority in the fields of hydraulic and electrical engineering. He was a member of the advisory committee for California in 1933; advisory engineer to the President's National Power Policy Committee on Preparedness, 1939–40; a member of the Colorado River Board of California, 1938–47; president of the American Public Power Association, 1947; and chairman of the Committee on Electric Power of California State War Council.

Harold John Allcock (M '31) deputy manager (production), the British Insulated Callender's Cables Company, Ltd., (formerly Callender's Cable and Construction Company, Ltd.), London, England, died recently. Born on April 23, 1897, at Eastbourne, Sussex, England, Mr. Allcock was graduated from the University College of South Wales in 1921 with a bachelor of science degree. From 1921 to 1923 he was a member of the college apprenticeship course offered by the Metropolitan-Vickers Electrical Company, Ltd., and served from 1924 to 1926 as a liaison engineer with the Westinghouse Electric Company, East Pittsburgh, Pa. He joined the Callender's Company the following year as technical assistant to the cable department manager, and subsequently was appointed assistant to the chief engineer, and process manager. In 1944 Mr. Allcock was named controller of the northern factories of the Callender's Company, and later, following that company's amalgamation with the British Insulated Cables Company, he was appointed deputy to the production director of the newly formed concern. Mr. Allcock was a director of several British companies and was a past chairman of the transmission section of the Institution of Electrical Engineers. He was also a member of the Institution of Mechanical Engineers.

Hugh Montgomery Stoller (M '19) technical staff, Bell Telephone Laboratories, New York, N. Y., died on November 17, 1947. Born in Schenectady, N. Y., on November 14, 1891, Mr. Stoller was a 1913 graduate of Union College from which he received an electrical engineering degree. From 1913 to 1914 he was engaged in engineering work for the Western Electric Company, New York, N. Y., but resigned from that job to take postgraduate study in engineering. In 1915 Mr. Stoller received a master of science degree in electrical engineering from Union College, afterwards becoming associated with the Western Electric Company, New York, N. Y., as a telephone engineer. He remained in that position until 1925 when he joined the staff of the newly formed Bell Telephone Laboratories. Mr. Stoller held more than 70 patents on voltage and speed regulators, and sound-picture equipment. During the past war he participated in the research projects of the laboratories on the electrical gun director, magnetic mines, and sonar, the underwater equivalent of radar. He was also the author of many technical papers. Mr. Stoller was a member of the Acoustical Society of America and a fellow of the Society of Motion Picture Engineers.

John George Hirsch (M '23) mechanical superintendent, St. Joseph Lead Company, Bonne Terre, Mo., died recently. Born in Milwaukee, Wis., on August 26, 1886, he was graduated from the University of Wisconsin in 1908 with a bachelor of science degree, and in 1911 with a civil engineering degree. Mr. Hirsch then was an assistant engineer with Daniel W. Mead, Construction Engineer, Madison, Wis., until 1913 when he accepted the position of construction engineer with the Bates and Rogers Construction Company, Chicago, Ill., and Spokane, Wash. In 1916 he was associated with the Stone and Webster Engineering Corporation, Boston, Mass., as a special assistant, in 1920 as supervising engineer with Lockwood, Greene and Company, Chicago, Ill., and in 1922 as principal assistant engineer, Benham Engineering Company, Kansas City, Mo. Mr. Hirsch became affiliated with the St. Joseph Lead Company in 1924 when he accepted a position with that firm as assistant mechanical superintendent. He was appointed in 1928 to the position which he held at the time of his death. Mr. Hirsch was also a member of the American Society of Civil Engineers.

Roy Collins Slack (M '46) budget engineer, American Gas and Electric Service Corporation, New York, N. Y., died recently. Born on November 22, 1901, in Lowmoor, Va., he was graduated from Washington and Lee University in 1925 with a bachelor of science degree in electrical engineering. From 1925 to 1936 Mr. Slack was employed as a meter engineer by the Appalachian Electric Power Company, Charleston, W. Va. In 1936 he accepted a position as general meter superintendent with the Atlantic City (N. J.) Electric Company, transferring to the Bridgeton, N. J., division of that company in 1941 as division manager. He resigned from that position in 1944 to become engineer-assistant to the vice-president and chief engineer for the American Gas and Electric Service Corporation, New York, N. Y., and in 1945 Mr. Slack was appointed executive engineer. He was a member of the National Society of Professional Engineers, and was a registered professional engineer in the State of New Jersey.

Sandor Ignatz Oesterreicher (A '07, M '19) electrical engineer, Metropolitan Device Corporation, Brooklyn, N. Y., died on October 31, 1947. Born in Budapest, Hungary, in 1875, he received his technical education from the Industrial School in Budapest. In 1896 Mr. Oesterreicher was graduated from the Engineer's School of the Austro-Hungarian Navy in Polia, Austria, as a marine-engineer. He came to the United States in 1900 and became a citizen of this country in 1908. From 1901 to 1904 Mr. Oesterreicher was a draftsman with the Sprague Electric Company, Bloomfield, N. J., and from 1904 to 1906 he served as first assistant to the chief of the production department of the Newark, N. J., works of the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation). He was employed in the engineering department of the New York Edison Company (now the Consolidated Edison Company of New York (N. Y.) Inc.) from 1906 to 1913, first as a designing draftsman and later as designer in charge. In 1913 he accepted a position with J. E. Murray as designing electrical engineer, and in 1914 he joined the Metropolitan Device Corporation staff as an assistant electrical engineer. Mr. Oesterreicher had written many papers for technological groups and scientific publications, and he was known particularly for his design of electric resistance welding machines and several types of current limiting reactors.

Wilson Kingman Page (A '10) president, Olean (N. Y.) Petroleum Company, died on August 6, 1947, according to a recently received report. Mr. Page was born in Olean, N. Y., on May 18, 1885. He attended Cornell University where he took an electrical engineering course and was graduated in 1909 with the degree of mechanical engineer.

MEMBERSHIP . . .

The board of examiners, at its meeting of November 20, 1947, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Clarke, E., prof. of elec. engg., Univ. of Texas, Austin, Tex.
deBellis, A. M., inside plant engr., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
MacMurchy, H. G., principal elec. engr., Ford, Bacon & Davis, Inc., New York, N. Y.
Matthews, H. D., consulting engr., W. M. Chace Co., Detroit, Mich.
Rowe, H., vice pres. & chief engr., United Fruit Co., Boston, Mass.
Tapy, R. W., head, dept. elec. engg., Univ. of New Mexico, Albuquerque, N. Mex.
Thomas, M. A., prof. elec. engg.; head, elec. engg. dept., New Mexico College of A & M Arts, State College, N. Mex.
Veinott, C. G., mgr., induction motor section, Westinghouse Elec. Corp., Lima, Ohio.
Willcutt, F. W., senior engr., Potomac Electric Power Co., Washington, D. C.

9 to grade of Fellow

To Grade of Member

Bailey, M. E., product engr., Sperry Gyroscope Co., Great Neck, N. Y.
Brown, J. S., major engr., mech. & elect. design, Boeing Aircraft Co., Seattle, Wash.
Butler, N. O., chief engr., The Design Engineering Co., St. Paul, Minn.
Chestnut, H., elec. engr., General Electric Co., Schenectady, N. Y.
Collett, C. S., plant supt., Avalon Telephone Co., St. Johns, Newfoundland.
Doggett, R. J., asst. elec. engr., Sanderson & Porter, New York, N. Y.
Gissel, E. A., head dispatcher, Centra Arizona Light & Power Co., Phoenix, Ariz.
Grant, G. III, laboratory head, Dow Corning Corp., Midland, Mich.
Hall, E. S., plant engr., Ripley Plant, Kansas Gas & Electric Co., Wichita, Kans.
Halpeny, O. M., engr., V. A. Hospital, Ft. Thomas, Ky.
Harman, E. N., chief testman, long lines, New York Telephone Co., Geneva, N. Y.
Hause, J., elec. engr., General Electric Co., Erie, Pa.
Harman, A. E., engr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Hood, H. C., design engr., Westinghouse Electric Corp., Sharon, Pa.
Howe, E. E., engr., Potomac Elec. Power Co., Washington, D. C.
Hudson, A. R., Girdler Corp., Louisville, Ky.
Humphrey, A. L., elec. engr., Tide Water Power Co., Wilmington, N. C.
Jessel, J. J. A., principal elec. engr., Federal Power Comm., Washington, D. C.
Lindstrom, L. O. B., co-partner, Smith & Lindstrom, San Francisco, Calif.
MacCarthy, D. D., section engr., General Electric Co., Pittsfield, Mass.
Obrecht, R. G., communication research & planning engr., Tennessee Valley Authority, Chattanooga, Tenn.
Oman, H., marine application engr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Pearson, D. B., development engr., General Electric Co., West Lynn, Mass.
Pickens, W. B., asst. district mgr., Texas Electric Service Co., Eastland, Tex.
Rice, D. N., Sr., junior engineer, Virginia Electric & Power Co., Alexandria, Va.
Shombert, G., Jr., asst. supt., test dept., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Sumner, W. A., division engr., Westinghouse Electric Corp., Sharon, Pa.
Tambling, R. L., member technical staff, Bell Telephone Labs., Inc., New York, N. Y.
Togesen, A. A., asst. sales mgr., Bull Dog Electric Products Co., Detroit, Mich.
Wagner, L. C. H., electrical contractor; pres., Wagner Electric Co. Inc., Miami, Fla.
Westover, T. A., project engr., Fairchild Camera & Instrument Corp., Jamaica, N. Y.

31 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before January 21, 1948, or March 21, 1948, if the applicant resides outside of the United States or Canada.

To Grade of Member

Arnold, F. E., General Elec. Co., West Lynn, Mass.
Barnes, W. H., Dept. of Water & Power, Los Angeles, Calif.
Barton, P., I. O. M. Electricity Board, Peel, Isle of Man, British Isles.
Bladholm, E. F., Southern Calif. Edison Co., Ltd., Los Angeles, Calif.
Caldwell, W. S., Jr., Roma Wine Co., Fresno, Calif.
Callicoat, K. L., The Chesapeake & Potomac Tel. Co. of W. Va., Charleston, W. Va.
Chevalier, H. B., A.C.E.C., Charleroi, Belgium.
Chock, R. C., Automatic Elec. Co., Chicago, Ill.
Clendenin, J. C., (re-election), 420 Lexington Ave., New York, N. Y.
DeWitt, C. O., Westinghouse Air Brake Co., New York, N. Y.
Dubé, R. J., Dubé Elec. Co., Waterbury, Conn.
Elliott, J. I. Glenn L. Martin Co., Middle River, Md.
Fitch, C. J., I. B. M. Corp., Endicott, N. Y.
Foster, R. W., Champion Paper & Fibre Co., Canton, N. C.
Gerlishe, T. O., Oakdale Irrigation District, Oakland, Calif.
Gunshol, W. J., Glenn L. Martin Co., Baltimore, Md.
Hall, W. N., Link Aviation, Binghamton, N. Y.
Helberg, R. J., Boeing Aircraft Co., Seattle, Wash.
Hervey, J. P., Univ. of Pennsylvania, Philadelphia, Pa.
Holden, A. C., Glenn L. Martin Co., Middle River, Md.
Holmquist, H. J., General Elec. X-Ray Corp., Milwaukee, Wis.
Knight, K. T., City of Rocky Mount, Rocky Mount, N. C.
Kolhoff, M. J., General Elec. Co., Erie, Pa.
Kulkarni, K. N., Public Works Dept., Nanpura, Surat, Bombay, India
Malmstrom, A. L., Detroit Edison Co., Detroit, Mich.
Piatt, D. R., I. B. M. Corp., Endicott, N. Y.
Popple, P. M., Automatic Elec. Co., Chicago, Ill.
Powell, L. L., Jr., J. S. Copeland Elec. Co., Inc., Houston, Tex.
Robinson, H. G., City of Austin, Austin, Tex.
Rogers, T. H., Machlett Labs., Inc., Springdale, Conn.

Schwartz, B. (re-election), Dept. of Water & Power Los Angeles, Calif.
Snyder, M. W., Dept. of Water & Power, Los Angeles, Calif.
Stapp, H., The Stapp Engg. Co., Denver, Colo.
Tankersley, H. A., Univ. of Texas, Austin, Tex.
Taylor, F. S., California Industrial Minerals Co., Friant, Calif.
Underwood, T. H., C. B. McCartney, St. Petersburg, Fla.
Walker, F. V., Dept. of Water & Power, Los Angeles, Calif.
Waterman, A. T., Office of Naval Research, Washington, D. C.
Warner, J. P., 204 Nixon Bldg., Pittsburgh, Pa.
Werk, E. W., Dept. of Water & Power, Los Angeles, Calif.

40 to grade of Member

To Grade of Associate

United States, Canada, Mexico, and Puerto Rico

1. North Eastern

Buford, P. N., General Elec. Co., Pittsfield, Mass.
Burke, F. B., Ferguson Elec. Constr. Co., Inc., Buffalo, N. Y.
Clentimack, G. E., Draper Corp. & Warner & Swasey Co., Plainville, Mass.
Curtiss, L. M., Thomas & Betts Co., Syracuse, N. Y.
Eaton, L. G., New England Power Service Co., Worcester, Mass.
Geer, H. W., Hartford Elec. Light Co., Hartford, Conn.
Gordon, N. B. (re-election), Chase Brass & Copper Co., Waterville, Conn.
Kline, A. D., General Elec. Co., Pittsfield, Mass.
Landers, T. P., Univ. of Conn., Storrs, Conn.
Reiss, W. K., Westcott & Mapes, New Haven, Conn.
Riddle, J. R., I.B.M. Corp., Endicott, N. Y.
Stewart, R. A., I.B.M. Corp., Endicott, N. Y.
Weidenhammer, J. A., IBM Corp., Endicott, N. Y.
Wright, B. G., General Elec. Co., Pittsfield, Mass.

2. Middle Eastern

Anderson, W. G., Westinghouse Elec. Corp., Pittsburgh, Pa.
Antel, J. S., Jr., George Washington Univ., Washington, D. C.
Baker, R. R., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Broussard, G. H., E. I. Du Pont de Nemours & Co., Wilmington, Del.
Byrd, J. D., Jr., Potomac Elec. Power Co., Washington, D. C.
Caputo, W. G., Westinghouse Elec. Corp., Baltimore, Md.
Carnine, R. L., Johns Hopkins Univ., Silver Spring, Md.
Colby, F. B., Westinghouse Elec. Corp., Sharon, Pa.
Detjen, E. R., Delaware Power & Light Co., Wilmington, Del.
Fones, E. C., Jr., Locke Insulator Corp., Baltimore, Md.
Green, D. B., Ohio Univ., Athens, Ohio
Hatfield, F. A., Line Material Co., Zanesville, Ohio
Hughes, A. V., Westinghouse Elec. Corp., Sharon, Pa.
Kirsch, J. I., Pennsylvania Railroad Co., Philadelphia, Pa.
Ksiazek, E., Lafayette College, Easton, Pa.
Laitinen, A., G. E. Supply Corp., Philadelphia, Pa.
Lundahl, W. N., Westinghouse Elec. Corp., Baltimore, Md.
McFarland, H. H., Bell Tel. Co. of Pennsylvania, Philadelphia, Pa.
Micinski, E., National Carbon Co., Inc., Cleveland, Ohio
Ollis, R. F., Jr., Westinghouse Elec. Corp., Lima, Ohio
Powell, E. H. (re-election), General Elec. Co., Wilmington, Del.
Reif, W. C., Philadelphia Elec. Co., Philadelphia, Pa.
Róbinson, H. L., Locke Insulator Corp., Baltimore, Md.
Roggenburk, R. W., Columbia Elec. Mfg. Co., Cleveland, Ohio
Romaine, W. R., David Taylor Model Basin, Carderock, Md.
Ryan, H. W., Westinghouse Elec. Corp., Baltimore, Md.
Shanahan, W. S., Anaconda Wire & Cable Co., Charleston, W. Va.
Smith, R. C., Philadelphia Elec. Co., Philadelphia, Pa.
Sodergren, C. J., Consolidated Gas & Elec. Co., Baltimore, Md.
Stewart, R. E., Jr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Zygmunt, H. J., Union Switch & Signal Co., Swissvale, Pa.

3. New York City

Delgrosso, A. L., Consolidated Edison Co., New York, N. Y.
Esteves, O. M., Jr., Puerto Rico Water Resources Authority, Santurce, Puerto Rico.
Hrynkiewich, W. F., Baker & Spencer, New York, N. Y.
Kasten, F. H., Allis-Chalmers Mfg. Co., New York, N. Y.
Lana, W. W., Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
McAuley, J. D. J., New York Tel. Co., Bronx, N. Y.
Milusich, A. A., (re-election), Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Rapp, C. P. (re-election), Intl. Tel. & Tel. Corp., New York, N. Y.
Riley, D. H., Radio Station WOV, Carlstadt, N. J.
Schwartz, L. J., Western Elec. Co., Newark, N. J.
Thompson, D. B., Thomas & Betts Co., Inc., New York, N. Y.
Zimmermann, T. K., Consolidated Edison Co. of N. Y. Inc., New York, N. Y.

4. Southern

Barrs, L. E., Alabama Power Co., Birmingham, Ala.
Baumann, W. C., W. H. Baumann & Son, Shreveport, La.
Carruthers, W. B., Aluminum Co. of America, Birmingham, Ala.
Cove, B. H., TVA, Chattanooga, Tenn.
Dunn, C. F., Williamson Sales Co., Shreveport, La.
Galbraith, B., Virginia Armature Co., Roanoke, Va.
Mueller, C. E., Memphis Light, Gas & Water Div., Memphis, Tenn.
Nierenberg, A. A., Univ. of Kentucky, Lexington, Ky.
Shea, E. F., Gulf States Utilities Co., Lake Charles, La.
Smith, K. C., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Switzer, A., Barnard & Burk, Baton Rouge, La.
Wever, L. R., Univ. of South Carolina, Columbia, S. C.
Whitson, R. C., Tenn. Coal, Iron & R.R. Co., Fairfield, Ala.

5. Great Lakes

Cameron, T. C., Sundstrand Machine Tool Co., Rockford, Ill.
Crawford, R. S., Cutler-Hammer, Inc., Milwaukee, Wis.
Davis, M. E., Western Elec. Co., Cicero, Ill.
Favia, M. L., Public Utility Engg. & Service Corp., Chicago, Ill.
Hart, H. A., Armour Research Foundation, Chicago, Ill.
High, V. L., Micro Switch, Freeport, Ill.
Hoppe, W. O., Jr., Harnischfeger Corp., Milwaukee, Wis.
Johnson, H. A., U.S. Rubber Co., Chicago, Ill.
Lietzke, I. R. (re-election), Public Service Co., Chicago, Ill.
Luther, S. W., Detroit Edison Co., Detroit, Mich.
Makela, H. W., Allis-Chalmers Mfg. Co., West Allis, Wis.
Mandarino, B., Automatic Elec. Co., Chicago, Ill.
Miller, P. T., Byerly Music Co., Peoria, Ill.
Nelson, M. W., Allen-Bradley Co., Milwaukee, Wis.
Neu, S. S. (re-election), Milwaukee School of Engg., Milwaukee, Wis.
Pollard, N. J., Univ. of North Dakota, Grand Forks, N.D.
Sanders, J. N., First Industrial Corp., Micro Switch Div., Freeport, Ill.
Sowden, H. J., Fergus Falls Water & Light Dept., Fergus Falls, Minn.
Stahl, T. J., Commonwealth Edison Co., Chicago, Ill.
Wallfred, J. E., Northwestern Bell Tel. Co., Des Moines, Iowa
Watland, G. M., Stanley Engg. Co., Muscantine, Iowa.
Wendt, R. R., Board of Public Works, Niles, Mich.
Williams, L. T., Westinghouse Elec. Corp., Chicago, Ill.

6. North Central

Hidy, J. W. (re-election), American Tel. & Tel. Co., Denver, Colo.
Lehman, R. H., Public Service Co. of Colorado, Denver, Colo.

7. South West

Benn, C. A., Southwestern Public Service Co., Plainview, Tex.
Brown, G. O., Burks Elec. Supply Co., Odessa, Tex.
Courte, F. E., Southwestern Bell Tel. Co., Dallas, Tex.
Dahlgren, C. A., Texas Elec. Service Co., Fort Worth, Tex.
Diaz L., E., Laboratorios Electricos Mexicanos, Mexico Federal District, Mexico
Egger, S. L., Petty Laboratories, Inc., San Antonio, Tex.
Hotard, J. G., Gulf States Utilities Co., Beaumont, Tex.
Jeffries, W. G., Trans World Airline, Kansas City, Kans.
Mizell, H. E., Southwestern Bell Tel. Co., Houston Tex.
Morris-Smith, P., General Cable Corp., Houston, Tex.
Neill, W. A., The Univ. of Texas, Austin, Tex.
Osorio R., E., Laboratorios Electricos Mexicanos, Mexico, Federal District, Mexico.
Padgett, J. D., Jr., Texas Elec. Service Co., Fort Worth, Tex.
Perdue, L. P., Jr., Southwestern Gas & Elec. Co., Texarkana, Ark.
Rhea, D. L., Elec. Storage Battery Co., Dallas, Tex.
Tucker, R. E., Southwestern Bell Tel. Co., Dallas, Tex.
Wallace, F. C., Black & Veatch, Kansas City, Mo.
Williams, J. D., Arkansas Elec. Co. ,Little Rock, Ark.

8. Pacific

Beyer, N. S., Bussmann Mfg. Co., San Francisco Calif.
Blaye, R. S., Southern Calif. Edison Co., Los Angeles, Calif.
Brabant, E. G., Sacramento Municipal Utility District, Sacramento, Calif.
Buffington, R. D., Bethlehem-Alameda Shipyard, Alameda, Calif.
Clare, W. F., Southern Calif. Edison Co., Los Angeles, Calif.
Eales, H. E. (re-election), Dept. of Water & Power, Los Angeles, Calif.
Farrar, B., Dept. of Water & Power, Los Angeles, Calif.
Finch, D. M., Univ. of Calif., Berkeley, Calif.
Garbellano, D. W., Univ. of Calif., Berkeley, Calif.
Golsan, P. E., Jr., Pacific Electro Sales, Inc., Los Angeles, Calif.
Gray, R. W., Herbert Rogers, Consultants, Oakland, Calif.
Henke, A. N., C. F. Braun & Co., Alhambra, Calif.
Herring, R. F., Herbert Rogers, Consultants, Oakland, Calif.
Hodges, D. A., Southern Calif. Edison Co., Los Angeles, Calif.
Hunter, C. M., Dept. of Water & Power, Los Angeles, Calif.
Ingalls, D. E., C. E. Ingalls, San Francisco, Calif.
Jones, W. S., Rockbestos Products Corp., Glendale, Calif.
Killam, L. V., Pacific Tel. & Tel. Co., San Francisco, Calif.
Kirkland, W. N. (re-election), Kaiser Co., Fontana, Calif.
Krieger, C. H., Clyde E. Bentley, Consulting Engr., San Francisco, Calif.
Marion, H. E., Pacific Tel. & Tel. Co., San Francisco, Calif.
McCallum, R. E. (re-election), Natl. Technical Labs., So. Pasadena, Calif.
McLaughlin, L. J., Dept. of Water & Power, Los Angeles, Calif.
Moline, V. C., Dept. of Water & Power, Los Angeles, Calif.
Myers, A. W., Ace Elec. Co., San Diego, Calif.
Otto, W. B., Arabian American Oil Co., San Francisco, Calif.
Pangborn, H. E., Calif. Elec. Power Co., Riverside, Calif.
Ready, R. W., Pacific Gas & Elec. Co., San Francisco, Calif.
Reading, J. E., City of San Diego, Calif.
Stevenson, W. A. S., Arizona Edison Co., Inc., Phoenix, Ariz.
Swanson, G. A., Dept. of Water & Power, Los Angeles, Calif.
Tarbox, C. F., US Bureau of Reclamation, Sacramento, Calif.
Tuft, V. E., Pacific Gas & Elec. Co., San Francisco, Calif.

9. North West

Blair, J. F., Boeing Aircraft Co., Seattle, Wash.
Bremer, H. B., Boeing Aircraft Co., Seattle, Wash.
Cartmell, T. R., Jr., General Elec. Co., Richland, Wash.
Danilson, L. W., Jr., Schwager-Wood Corp., Portland, Oreg.
Dillon, P. L. (re-election), General Elec. Co., Portland, Oreg.
Dobson, L. S., General Elec. Co., Richland, Wash.
Haynes, R. F. (re-election), General Elec. Co., Richland, Wash.
Sargent, C. S. (re-election), Boeing Aircraft Co., Seattle, Wash.
Schuler, E. H., Washington Water Power Co., Spokane, Wash.
Sweeney, P. M., Pac. Tel. & Tel. Co., Portland, Oreg.

10. Canada

Henselwood, E. W., Canadian General Elec. Co., Ltd., Toronto, Ontario, Canada.
Kennedy, R. W., Waterous Ltd., Brantford, Ontario, Canada
Lambert, G. K., T. Pringle & Son, Ltd., Montreal, Quebec, Canada
White, W. H., Canadian Line Materials, Ltd., Toronto, Ontario, Canada

Elsewhere

De Bhavnani, H., All India Radio, New Delhi, India
Godaux, O. L., c/o SOGEFOR, Jadotville, Belgian Congo.
Mohtadi, M., Anglo-Iranian Oil Co., Ltd., Abadan, Iran
Redfern, G., British Thompson Houston Co., Ltd. Rugby, England
Schiller, H. J. (re-election), Motor Columbus S. A., Baden, Switzerland
Small, G. R., Messrs. Bruce Peebles & Co., Ltd., Edinburgh, Scotland
Tuckfield, G. L., Metropolitan-Vickers Elec. Co., Ltd., Manchester, England
Vyas, C. S., Rohtas Industries Ltd., Dalmianagar, Bihar, India

Total to grade of Associate

United States, Canada, Mexico, and Puerto Rico, 160
Elsewhere, 8

AIEE Technical Subcommittees

As it has been proved that so much of the groundwork of technical committee projects is accomplished within the subcommittee, it is fitting that a delineation of the structure and personnel of these important subgroups follow the explanation of the main committee structures and organization (*EE, Oct '47, pp 1006–11 and 1031–35*).

The purposes and advantages should be twofold:

1. To benefit the AIEE membership in general by depicting in further detail the scope of the technical committee organization previously given and by providing more information on the important work going on in these committees while it is in the formative stage.
2. To provide potential benefit to the committees themselves by encouraging Institute members and others to avail themselves of every possible opportunity to make suggestions on subcommittee projects and to offer their services to the subcommittee, even as prospective members if they so desire.

The subcommittee (sometimes called working group or project committee) is the usual means for implementing the more definite projects in the technical committees of the Institute when the concentrated attention of a selected group of specialists is indicated. When the main committee or its chairman decides that a particular project coming within its scope requires temporary or continual attention, the chairman appoints a subcommittee chairman and the subcommittee members with the assistance of that chairman.

Subcommittee members are not necessarily members of the main or parent committee nor need they be members of the AIEE, so that the greatest possible degree of freedom is provided for selecting the requisite talent for the subject to be studied. Liaison with other societies and with other committees of the Institute is accomplished easily because of this freedom. Also, engineers not members of the AIEE are given an opportunity of observing and working with AIEE groups, which oftentimes results in the acquisition of otherwise unavailable talent for committee activities.

Many subcommittees whose assignment is broad remain in existence as standing organizations from year to year, changing their personnel and active projects as necessity demands. Others, whose purpose is limited, are discharged when their work reaches a satisfactory conclusion. The establishment or discharge of a subcommittee is done usually at the discretion of the main committee chairman who can formalize the action by vote of the main committee.

Subcommittees work as semiautonomous bodies pursuing their assignment as expediency dictates, principally by correspondence but holding meetings on their own initiative if necessary. However, they report progress and conclusions *only* to the parent technical committee through minutes, reports, and via their chairman or other members who may be members simultaneously of that parent committee.

In this and subsequent issues of *ELECTRICAL ENGINEERING* will be found the personnel and, where available, a short statement of scope for each of the subcommittees of the 30 technical committees of the Institute. It should be understood that any statement here of scope is not restrictive and is subject to change throughout the year. They are offered solely to give the Institute member who ordinarily does not come in contact with these committees an idea of the type of work being undertaken. Personnel also are subject to minor changes through the year with more substantial changes at the beginning of each new Institute year (August 1).

In the present issue, the subcommittee organization of the 12 main committees of the power group is outlined as it existed on December 1, 1947. In subsequent issues, the subcommittees of the industry group, communication and science group, and general applications group will be published.

Power Group Subcommittees

Carrier Current Committee

1. Project—Preparation of a General Interest Paper on Carrier Current

Scope: This paper is to give a historical review of the carrier developments and outline the place the carrier has in present-day system operating practices.

J. D. Booth, *chairman*
S. C. Bartlett
L. F. Kennedy

2. Project Committee Report on Application Guidance for Carrier Current

D. M. MacGregor, *chairman*
C. W. Boadway
T. D. Talmage

3. Working Group to Prepare Suggested Methods of Measurement

Scope: Establishment of methods of measurements in the carrier field.

E. W. Kenefake, *chairman*
S. C. Bartlett
C. W. Boadway
M. H. Wood

4. Working Group on High-Frequency Characteristics of Power Equipment

S. C. Leyland, *chairman*
T. A. Cramer

5. Working Group for Data on Carrier-Current Characteristics of Transmission Lines and Systems

Scope: Power system measurements at carrier frequency dealing primarily with transmission lines and substations.

R. C. Erickson, *chairman*
W. J. Googe
L. E. Ludekens
T. D. Talmage

6. New Projects to Be Undertaken When Personnel and Other Conditions Permit

(*a*). Standard terminology for carrier current.

(*b*). Carrier-current frequency characteristics of capacitance potential devices.

(*c*). Carrier current characteristics of lightning arresters.

(*d*). Coupling capacitors and traps for rural line carrier telephone.

(*e*). Use of microwave equipment for relaying, telemetering, and supervisory control.

Electronic Power Converter Committee

1. Policy and Planning Subcommittee

Scope: The function of this subcommittee is to plan and co-ordinate the activities of the main committee and its subcommittees. It will consist of the officers and the preceding chairman of the main committee, the chairmen of the subcommittees, and any other committee members designated by the chairman.

Main Committee Officers:
H. Winograd, *chairman*
C. C. Herskind, *vice-chairman*
H. C. Steiner, *secretary*
C. H. Willis, *preceding chairman*
Subcommittee Chairmen:
C. R. Marcum
D. E. Marshall
A. J. Maslin
L. W. Morton
Joel Tompkins

2. Electronic Converter Application Subcommittee

Scope: This subcommittee will handle matters relating to the application and operation of electronic power converters, such as rating, installation, operation, maintenance, inductive co-ordination.

L. W. Morton, *chairman*
Joel Tompkins, *cochairman*
F. W. Cramer
J. B. Donnelly
Wm. Fraser
W. E. Gutzwiller
C. S. Hague
H. E. Houck
W. J. L. Rupprecht
S. L. Smith
O. J. Swanson
T. A. Taylor
J. T. Thwaites

3. Electronic Converter Circuits Subcommittee

Scope: This subcommittee will handle matters relating to circuit theory, protection, and control of electronic power converters. It will co-operate with the other subcommittees and with other AIEE committees (such as electronics, switchgear, protective devices substations) on matters of mutual interest.

C. C. Herskind, *chairman*
J. L. Boyer
E. V. DeBlieux
I. K. Dortort
G. N. Hughes
G. F. Jones
A. Schmidt, Jr.
T. A. Taylor
C. H. Willis
H. Winograd

4. Papers and Speakers Subcommittee

Scope: This subcommittee will complete the bibliography on electronic power converters and will keep it up to date with annual supplements. It will make recommendations on subjects for technical papers and promote the preparation of such papers. It will prepare information on the availability of speakers and educational material on electronic power converters, as an aid to schools, AIEE Sections, and discussion groups.

C. R. Marcum, *chairman*
J. B. Rice
J. T. Thwaites
H. E. Zuvers

5. Rectifier Transformers Subcommittee

Scope: This subcommittee will handle matters relating to transformer equipment used for electronic power converters. It will maintain liaison with the AIEE transformer committee, to keep the two committees informed on matters of mutual interest.

A. J. Maslin, *chairman*
E. V. DeBlieux
W. C. Sealey

6. Rectifying Devices Subcommittee

Scope: This subcommittee will handle matters relating to design and characteristics of rectifying devices used for electronic power converters. It will maintain liaison and co-operate with other technical committees of the AIEE and other organizations which carry on activities relating to such rectifying devices, and it will keep the electronic power converter committee informed on such activities.

D. E. Marshall, *chairman*

7. Other Projects from Last Year:

(*a*). Preparation of report on protection of electronic power converters. By electronic converter circuits subcommittee; C. C. Herskind, chairman of working group.

(*b*). Bibliography on electronic power converters. By papers and speakers subcommittee; C. R. Marcum, chairman of working group.

(*c*). Report on European developments in design and application of electronic power converters; J. T. Thwaites, chairman of working group.

8. New Projects:

(*a*). Progress report on mercury-arc electronic power converters, for presentation at the AIEE summer general meeting in Mexico City, June 1948.

Working group members:

C. R. Marcum
L. W. Morton
H. C. Steiner
H. Winograd

(*b*). 1. Prepare forms for collecting application, operating, and maintenance data on mercury-arc power converters.

2. Collect data on a-c system characteristics and load characteristics in rectifier installations for various industries.

3. Power metering in rectifier installations. By electronic converter application subcommittee; L. W. Morton, chairman.

(*c*). Prepare report on inductive co-ordination relating to d-c side of rectifier installations. By electronic converter application subcommittee; T. A. Taylor, chairman of working group.

(*d*). Sponsor conference on mechanical rectifiers at the AIEE winter general meeting, January 1948. Papers will be presented by J. T. Thwaites, Walther Richter, Otto Jensen, B. D. Bedford.

Insulated Conductor Committee

1. Administration Subcommittee

Scope: The activities of this subcommittee include subcommittee organization and scopes, co-ordination of subcommittee activities, program planning, and selection of papers for national meetings.

Main Committee Officers:

L. F. Hickernell, *chairman*
H. Halperin, *vice-chairman*
C. T. Hatcher, *secretary*
R. J. Wiseman

Subcommittee Chairmen:

J. C. Balsbaugh
A. S. Brookes
W. A. Del Mar
J. H. Foote
T. G. Hieronymus
G. T. Koger
L. I. Komives
W. T. Peirce
H. S. Phelps
Gordon Thompson
C. P. Xenis

2. Standards and Publications Subcommittee

A. S. Brookes, *chairman*
A. S. P. Bellis
L. E. Fogg
J. H. Foote
V. A. Sheals
C. W. Zimmerer

Projects:

(*2-1*). Standard number 30 (1944)—revision
(*2-2*). Insulated Conductor Reference Book

3. Cable Characteristics Subcommittee

W. A. Del Mar, *chairman*
H. Halperin
C. T. Hatcher
C. G. Mansfield
M. H. McGrath
J. H. Neher
J. L. Neuman
G. B. Shanklin
F. V. Smith
R. J. Wiseman

Projects:

(*3-1*). Current-carrying capacity of buried cables
(*3-2*). Zero-sequence impedance of cables
(*3-3*). A-c resistance of cables in conduit (paper)
(*3-4*). Reactance of cables in conduit (paper)

4. Conductors Subcommittee

J. H. Foote, *chairman*

Projects:

(*4-1*). Determination of conductor resistivity
(*4-2*). Definition of terms relating to conductors
(*4-3*). *NBS* circular number 31—revision

5. Insulations Subcommittee

J. C. Balsbaugh, *chairman*
C. F. Avila
C. E. Betzer
F. M. Clark
E. W. Greenfield
J. D. Piper
R. A. Schatzel
G. M. L. Sommerman
A. J. Warner
K. S. Wyatt

Projects:

(*5-1*). Properties of synthetic rubber and plastics
(*5-2*). Properties of impregnating oils

6. Sheaths and Coverings Subcommittee

H. S. Phelps, *chairman*
C. E. Betzer
A. S. Brookes
G. H. Fiedler
F. E. Kulman
A. D. Pettee
V. A. Sheals
G. W. Zink

Projects:

(*6-1*). Properties of lead and lead alloy sheathing
(*6-2*). Properties of nonmetallic sheaths
(*6-3*). Protective covering for lead sheathing
(*6-4*). Evaluation of simulated service tests on lead sheathing
(*6-5*). Determination of tensile strength of lead sheathing
(*6-6*). Movement of buried cable

7. Cable Supply Systems Subcommittee

L. I. Komives, *chairman*
C. F. Avila
H. G. Barnett
T. J. Brosnan
W. R. Bullard
H. W. Clark
D. M. Farnham
H. Halperin
C. T. Hatcher
A. D. Pettee
C. S. Schifreen
G. B. Shanklin
O. W. Titus
R. J. Wiseman
K. S. Wyatt

Projects:

(*7-1*). 138-kv polyethylene-sheathed compression cable—pipe-line type (paper)
(*7-2*). 115-kv high-pressure oil-filled pipe cable installation at New Orleans, La. (paper)
(*7-3*). 69-kv cable installations at Philadelphia (paper)
(*7-4*). Thermal characteristics of 120-kv high-pressure gas-filled cable installation (paper)
(*7-5*). 69-kv cable installation at Milwaukee (paper)
(*7-6*). Nonmetallic sheathed cable in ducts for primary distribution
(*7-7*). Nonmetallic sheathed cable in ducts for secondary distribution
(*7-8*). Buried cable for distribution systems
(*7-9*). Aerial cable for distribution systems

8. Utilization Wiring Systems Subcommittee

G. T. Koger, *chairman*
E. L. Bailey
H. G. Barnett
Allen Coggeshall
C. A. Finkel
M. G. Houghton
M. J. Lowenberg
J. B. MacLean
L. C. Peterman
Kennard Pinder
S. J. Rosch
C. V. Waddington
C. W. Zimmerer
G. W. Zink

Projects:

(*8-1*). Primary distribution systems for industrial plants
(*8-2*). A-c network systems for industrial plants
(*8-3*). Power station auxiliary cables
(*8-4*). Ring-bus wiring systems

9. Special Purpose Cables Subcommittee

W. T. Peirce, *chairman*
M. T. Crawford
E. W. Davis
S. F. French
R. A. Hopkins
G. H. Landis
M. J. Lowenberg
H. S. Moore
L. M. Moore
W. N. Zippler
Myron Zucker

Projects:

(*9-1*). Standard number 45—sections 18, 19, 20 (1945)—revision
(*9-2*). American versus foreign shipboard cable practice
(*9-3*). Mining cable
(*9-4*). Vertical-riser cable

10. Accessories Subcommittee

T. G. Hieronymus, *chairman*
C. Christianson
C. D. Eash
M. W. Ghen
J. E. Johnson
H. E. Martin
R. E. Morse
J. H. Nicholas
E. F. Nuezel
F. P. West
L. Wetherill

Projects:

(*10-1*). Standard number 48 on cable potheads (1948)—discussion
(*10-2*). Termination of nonmetallic sheathed cables

11. Structures Subcommittee

C. P. Xenis, *chairman*
C. E. Baugh
Andrew Bodicky
T. J. Brosnan
H. W. Clark
H. L. Davis, Jr.
C. D. Eash
G. H. Fiedler
C. G. Mansfield
R. S. Peterson
L. G. Smith

Projects:

(*11-1*). Conduits
(*11-2*). Gases in underground structures
(*11-3*). Transformer manhole and vault design and ventilation
(*11-4*). Manhole construction
(*11-5*). Supports for aerial cable
(*11-6*). Supports for bridge cable
(*11-7*). Under river crossings

12. Tests and Measurements Subcommittee

Gordon Thompson, *chairman*
J. C. Balsbaugh
A. L. Brownlee
R. W. Chadbourn
E. W. Davis
W. A. Del Mar
E. W. Greenfield
E. S. Halfmann
F. K. Harris
J. C. Parker
G. M. L. Sommerman
E. R. Thomas
R. J. Wiseman
C. W. Zimmerer

Projects:

(*12-1*). Test code for insulated conductors
(*12-2*). Equivalent 1-hour life for oil-filled and gas-filled cable
(*12-3*). High-frequency measurements
(*12-4*). A-c resistance and reactance measurements
(*12-5*). Impulse strength testing

Power Generation Committee

1. Prime Movers Subcommittee

Scope: To study, review design, installation practices, and other features of all types of prime movers and their associated equipment (except hydraulic units) as related to electric power generation. To sponsor specifications, Standards, and technical sessions, the latter to be devoted principally to new developments or review of existing practices. To co-operate with other committees of organizations such as American Society of Mechanical Engineers and Edison Electric Institute.

B. G. A. Skrotzki, *chairman*
S. Beckwith
F. W. Gay
H. R. Harris
J. A. Powell
H. D. Taylor

2. Speed Governing Subcommittee

Scope: To study, review design, installation practices, and other features of all types of prime-mover governing systems, including hydroelectric. To sponsor specifications, Standards, and technical sessions and co-operate with other committees of the AIEE and other societies.

M. J. Steinberg, *chairman*
J. B. McClure
G. H. McDaniel
F. L. Reinmann

3. Excitation Systems Subcommittee

Scope: Similar functions as for the speed-governing subcommittee in the field of generating-station excitation systems.

A. J. Krupy, *chairman*
J. B. McClure, *vice-chairman*
E. F. Dissmeyer
A. Dovjikov
J. H. Kinghorn
H. A. P. Langstaff
T. B. Montgomery
F. D. Troxel
R. L. Witzke

4. Station Design Subcommittee

Scope: To review designs and installation practices in electric generating stations considered as a unit. To sponsor technical sessions covering new or improved practices. To analyze trends and designs and present general interest material of future possibilities. This subcommittee will not cover hydroelectric stations.

A. D. Caskey, *chairman*
C. A. Corney
R. P. Crippen
E. L. Hough
W. R. Johnson

5. Hydroelectric Systems Subcommittee

Scope: Combining the scope, for hydroelectric stations only, of the prime movers and station design subcommittees.

J. B. McClure, *chairman*
S. M. Denton
B. V. Hoard
J. Y. Madill
W. S. Peterson
A. L. Pollard
G. R. Woodman

6. Operating Statistics Subcommittee

Scope: To collect and correlate statistical data pertaining to power generation, including operating costs and performance, and data on plant and system design. Functions to be defined more fully as assignments develop.

G. M. Pollard, *chairman*
J. M. Drabelle
C. A. Harrington
G. M. Tatum

7. Pacific Coast Subcommittee

Scope: To foster closer co-operation with the western members in all projects undertaken by the main committee. To provide direct contact in the planning of Pacific Coast technical meetings.

W. S. Peterson, *chairman*
A. Dovjikov
W. R. Johnson
A. L. Pollard
G. R. Woodman

Protective Devices Committee

1. Lightning Protective Devices Subcommittee

H. R. Stewart, *chairman*
F. M. Defandorf
R. H. Earle
Milan Getting
I. W. Gross
E. H. Grosser
H. W. Hartzell
T. W. Mawson
J. R. McFarlin
W. A. McMorris
A. M. Opsahl
W. E. Rushlow
A. H. Schirmer
J. M. Towner
E. R. Whitehead
E. H. Yonkers

Project 1: Application guide of methods for lightning protection of substations.

The scope of this project includes the selection of arrester ratings as determined by system operating conditions and the protective level required by the insulation to be protected, effects of length of electrical connections between the arrester location and protected equipment, effects of station grounding conditions, application of shielding wires and masts, effects on substation local protective requirements when incoming lines are protected by ground wires or are underground, and so forth.

Project 2: Expulsion-type distribution lightning arrester performance characteristics.

A. M. Opsahl, *chairman*
L. L. Crump
R. H. Earle
D. D. McCarthy
C. E. Mosley
C. L. Stroup
E. H. Yonkers

Project 3: Survey of the lightning protective equipment used on a-c rotating machines.
T. H. Mawson, *chairman*

Project 4: Lightning protection for unit substations.

The scope of this project will be to survey the technical background and recommend solutions for the problem where pothead-type transformers frequently used in unit substations are connected directly to cables in such a manner that it is impractical to install lightning protective devices directly at the transformer terminals, but where the cables between the transformer and overhead exposure are sufficiently short so that a lightning exposure to the transformer exists.

E. R. Whitehead, *chairman*
H. W. Hartzell
E. M. Hunter
A. A. Johnson
J. M. Towner

Project 5: To combine and revise AIEE Standards 24, 28, and 47.

F. M. Defandorf, *chairman*
R. H. Earle
I. W. Gross
E. H. Grosser
. R. McFarlin
W. A. McMorris
A. M. Opsahl
W. E. Rushlow
A. H. Schirmer
J. M. Towner
E. H. Yonkers

New Projects (to be undertaken when time and facilities permit):

(*a*). Report on distribution system rate of rise of recovery voltage rates for use in formulating suitable duty cycle test standards on distribution-type expulsion arresters.

(*b*). Report on the application of lightning arresters to serial cables used on distribution circuits.

(*c*). Report on the application of surge absorbers on the secondaries of mercury arc rectifier transformers.

2. Fault Limiting Devices Subcommittee

A. A. Johnson, *chairman*
E. M. Hunter
W. T. Smith
E. T. B. Gross
P. A. Jeanne
H. W. Hartzell
W. E. Marter
O. L. Sidenfaden
W. A. Lewis
E. W. Knapp
W. W. Eberhardt
E. R. Longley
J. E. Clem
E. G. Norell

Project 1: Application guide on methods of grounding transmission systems.
E. M. Hunter, *chairman*

Project 2: Application guide on methods of grounding generator systems.
A. A. Johnson, *chairman*

Project 3: Special neutral devices applied for inductive co-ordination.

The scope of this project will consist of the report on special neutral grounding devices which have been applied for reducing or eliminating communication interference difficulties.

W. T. Smith, *chairman*
C. W. Frick
P. A. Jeanne
T. A. Taylor
H. W. Wahlquist

Project 4: Bibliography of literature on grounding devices.
E. T. B. Gross, *chairman*

Project 5: Field survey of and application problems associated with ground fault neutralizers.
J. E. Clem, *chairman*

Project 6: Power system fault limitation.

The scope of this project will consist of a report on ways and means of limiting short-circuit kilovolt amperes on new and old systems with particular reference to the use of series reactors.
F. R. Longley, *chairman*

Relay Committee

1. Project Committee on Bibliography of Relay Literature

C. E. Parks, *chairman*
S. Goldsmith
C. L. Smith

2. Project Committee on Generator Protection

H. R. Paxson, *chairman*
J. C. Bowman
L. L. Draper
B. C. Hicks
S. C. Leyland
H. F. Lindemuth
W. E. Marter
J. B. McClure
A. J. McConnell
C. E. Parks
F. C. Poage
C. L. Smith

3. Project Committee on Co-ordination of Construction and Protection of Distribution Circuits (Joint with Distribution Subcommittee and Edison Electric Institute)

G. B. Dodds, *AIEE sponsor*
C. J. Beller, *EEI sponsor*

Relay Committee Appointees:	*Distribution Subcommittee Appointees:*	*EEI*
H. W. Haberl	R. O. Askey	G. H. Fiedler
C. L. Headley	T. J. Brosnan	W. Mclean
C. Lowerison	W. B. Fisk	E. W. Knapp
C. E. Parks	A. L. Malmstrom	
H. P. Sleeper	H. F. Osterman	
C. L. Smith	J. S. Parsons	
	R. F. Quinn	

4. Project Committee on Revision of Standards for Power Relays

S. C. Leyland, *chairman*
J. C. Bowman
R. E. Cordray
V. L. Cox
L. L. Fountain
W. A. Lewis
E. L. Michelson

5. Project Committee on Sensitive Ground Protection

E. T. B. Gross, *chairman*
C. J. Berghs
R. J. Cooper
T. R. Halman
P. A. Jeanne
C. Lowerison
W. K. Sonnemann
A. R. van C. Warrington

6. Project Committee on Transmission Line Protection

E. L. Harder, *chairman*
L. J. Audlin
W. R. Brownlee
B. C. Hicks
J. H. Kinghorn
W. A. Lewis
W. E. Marter
A. J. McConnell
M. S. Merritt
E. L. Michelson
C. E. Parks
K. N. Reardon

7. Project Committee on Electronic Relay Applications

A. J. McConnell, *chairman*
J. E. Barkle
R. J. Cooper
F. S. Fehr
E. L. Harder
J. H. Kinghorn
D. M. McGregor
E. L. Michelson
E. G. Ratz

8. Project Committee on Insulation Levels of Relays and Control Circuits

E. L. Michelson, *chairman*
R. E. Cordray
S. Goldsmith
T. R. Halman
V. J. Hayes
W. K. Sonnemann

9. Project Committee on Relaying of Interconnections Between Industrial and Utility Generating Systems

K. N. Reardon, *chairman*
J. E. Barkle
G. E. Dana
F. S. Fehr
T. R. Halman
J. R. Linders

10. Projection Committee on Relay Protection for Stations Without High-Voltage Switching

E. L. Michelson, *chairman*
L. F. Ferri
L. L. Fountain
V. J. Hayes
R. A. Larner
K. N. Reardon

11. Proposed Future Projects:

(*a*). Capacitance potential device transient performance as influencing relay operation.
(*b*). Review of bus protection methods and performance.
(*c*). Relay protection of circuits following sustained interruptions.
(*d*). A-c and low-voltage d-c tripping methods (joint).
(*e*). Relay test methods.
(*f*). Switching schemes influencing relay protection.
(*g*). Ultrahigh-frequency radio protective relay applications.
(*h*). Design and protection of pilot-wire channels.
(*i*). Uniform records of relay performance.

Rotating Machinery Committee

1. Administrative Subcommittee

C. E. Kilbourne, *chairman*
W. R. Hough
M. F. Kent
T. M. Linville
T. C. Lloyd
E. I. Pollard
F. C. Rushing
M. L. Schmidt
R. W. Wieseman

2. Synchronous Machinery Subcommittee

E. I. Pollard, *chairman*
Sterling Beckwith
J. F. Calvert
S. B. Crary
J. DeKiep
L. O. Dorfman
A. M. Goodison, Jr.
E. L. Harder
R. A. Hopkins
L. F. Hunt
C. E. Kilbourne
G. W. McIver
W. P. Monroe
J. G. Noest

3. Induction Machinery Subcommittee

F. C. Rushing, *chairman*
E. L. Bailey
E. C. Barnes
B. M. Cain
S. F. Henderson
Charles Kingsley, Jr.
C. J. Koch
T. C. Lloyd
R. C. Moore
J. G. Noest
C. P. Potter
P. H. Trickey

4. D-C Machinery Subcommittee

T. M. Linville, *chairman*
W. E. Clancy
F. A. Compton
Lanier Greer
L. N. Grier
J. L. Hamilton
C. B. Hathaway
V. P. Hessler
P. Lebenbaum
C. Lynn
D. Ramadanoff
J. F. Sellers

5. Single-Phase and Fractional-Horsepower Subcommittee

M. L. Schmidt, *chairman*
W. R. Appleman
B. M. Cain
I. M. Levy
R. F. Munier
P. H. Trickey
C. G. Veinott
N. S. Yost

6. Test Code Subcommittee

Scope: This committee is charged with the responsibility of preparing and keeping up to date all codes applying to the lines of apparatus assigned to them.
T. C. Lloyd, *chairman*
T. E. M. Carville

7. Insulation Resistance Subcommittee

R. W. Wieseman, *chairman*
(*Personnel to be selected.*)

Substation Committee

1. Executive Subcommittee

Scope: To plan and co-ordinate the activities of the main committee and its subcommittees including consideration of their scopes, program planning, and assistance in selection of papers.
Main Committee Officers:
G. S. Whitlow, *chairman*
G. S. Lunge, *vice-chairman*
I. T. Knight, *secretary*
(*Subcommittee chairmen and personnel to be selected.*)

2. High-Voltage Outdoor Substation Subcommittee

Scope: Responsible for treatment of all problems of structural and electrical design, construction and arrangement of these substations known as transmission substations.
(*Subcommittee chairmen and personnel to be selected.*)

3. Low-Voltage Indoor and Outdoor Substation Subcommittee

Scope: Responsible for treatment of all problems of structural and electrical design, construction and arrangement of those substations known as distribution substations.
(*Subcommittee chairmen and personnel to be selected.*)

4. Control and Wiring Diagram Subcommittee

Scope: Responsible for treatment of all problems relating to the development of automatic, remote, and manual control, and also fundamental electrical diagrams pertaining to substations.
(*Subcommittee chairmen and personnel to be selected.*)

Switchgear Committee

1. Circuit Breaker Subcommittee

C. H. Black, *chairman*
F. W. Cramer
R. M. Ferrill
W. Hardaway
M. H. Hobbs
W. J. McLachlan
J. R. North
H. V. Nye
F. V. Smith
J. H. Vivian
R. L. Webb
K. L. Wheeler
J. D. Wood
J. C. Woods

The following working groups have been set up within this subcommittee:

A—Power circuit breakers.
B—Low-voltage air circuit breakers.
C—Automatic reclosers.
D—Calculations of short-circuit currents in low-voltage systems.

2. Switchgear Assemblies Subcommittee

H. V. Nye, *chairman*
F. W. Cramer
J. M. Geiger
C. H. Kreger
E. F. Miller
G. M. Reed
H. H. Rudd
B. K. Sturgis
O. B. Vikoren
C. P. West
W. F. Wetmore

3. Switches, Fuses, and Insulators Subcommittee

H. H. Rudd, *chairman*
K. J. C. Falck
A. H. Powell
H. L. Rawlins
R. L. Webb
J. C. Woods

The following working groups have been set up within this subcommittee:

A—Air switches and insulators (H. L. Rawlins, *chairman*).
B—Interrupter switches (H. H. Powell, *chairman*).
C—Fuses (R. L. Webb, *chairman*).

Incompleted Projects:

The incompleted projects carried over from the protective devices committee of 1946–7 are

(*a*). Completion of Standards for automatic reclosers for a-c distribution circuits.
(*b*). Revision of Switchgear Assembly Standard 27.
(*c*). Review Standards for low-voltage air circuit breakers, which were issued for a one year trial period in December 1946.
(*d*). Complete work on calculations of short-circuit currents for low voltage.
(*e*). Complete work on revisions of short-circuit calculation and application factors for power circuit breakers.
(*f*). Complete test code for power circuit breakers.
(*g*). Revise AIEE Standard 19 (ASA *C-37*) to include temperature limits for oilless circuit breakers.
(*h*). Study rating factors for oil and oil-less circuit breakers.
(*i*). Complete revisions of AIEE Standard 22 for air switches and bus supports.

New Projects:

(*a*). Study of H. H. Rudd's proposed supplement to AIEE Standard 2, Guiding Principles for Impulse Insulation Co-ordination.
(*b*). Prepare a test code for low-voltage circuit breakers.
(*c*). Prepare Standards for automatic short-circuiting devices.
(*d*). Co-operate with ASA *C-42* Committee on revisions of "Definitions of Electrical Terms."

System Engineering Committee

1. Administrative Subcommittee

Scope. To serve as an executive committee in the assignment of work to subcommittees, to expedite work and to arrange for preparation and presentation of papers at meetings.

J. E. McCormack, *chairman*
R. Brandt
H. L. Harrington
A. P. Hayward
R. G. Hooke
L. F. Hunt
B. M. Jones
C. W. Mayott
O. W. Manz, Jr.
E. Wild

2. System Planning Subcommittee

Scope: Investigation and study of load growth and generation requirements, interconnection of systems, methods of transmission and interconnection, location and optimum sizes of units, and general system planning studies.

H. L. Harrington, *chairman*
R. Brandt
S. B. Crary
E. T. B. Gross
W. D. Hardaway
J. B. Hodtum
R. G. Hooke
A. A. Johnson
B. M. Jones
A. A. Kroneberg
H. P. St. Clair
N. N. Smeloff
M. L. Waring

3. System Operations Subcommittee

Scope: Investigation and study of load and kilovar dispatching, spinning reserve, emergency procedures, resynchronizing procedures, requirements and usage of communication equipment, safety "hold-off procedures," functions of intersystem operating committees, and other general studies for improvement of system operation.

E. Wild, *chairman*
M. L. Blair
G. Bissett
L. F. Hunt
R. M. Laurie
O. W. Manz, Jr.
F. Oppenheimer
H. W. Phillips
W. O. Smith

4. System Economics Subcommittee

Scope: Investigation and study of interconnection operation, economics of long high-voltage power transmission, co-ordination of operation of units in a plant, between plants in a system, and between systems and other economic studies for improved system operation.

A. P. Hayward, *chairman*
E. C. Brown
E. E. George
C. B. Kelly
V. M. Marquis
R. T. Purdy
J. A. Rose

5. System Controls Subcommittee

Scope: Investigation and study of load-frequency control equipment and operation, voltage control, phase angle control, and other general studies of control methods to improve system operations.

R. Brandt, *chairman*
S. B. Morehouse, *vice-chairman*
C. G. Adams
C. P. Almon, Jr.
D. H. Cameron
T. E. Curtis
A. A. Johnson
C. N. Metcalf
R. E. Pierce
S. A. Tucker

6. Interconnection Contracts Subcommittee

Scope: Investigation and study as to important features of interconnection contracts, economic interchange, emergency requirements and metering requirements, and other matters of interest to improve interconnection relations.

C. W. Mayott, *chairman*
E. D. Early
E. E. George
G. A. Grimm
N. B. Hinson
C. B. Kelly
M. L. Lovelady
V. M. Marquis
Roy Martindale

Transformer Committee

1. Instrument Transformer Subcommittee

Transformer Committee Representatives:

J. E. Clem, *chairman*
E. C. Wentz
D. R. Laib

Relay Committee Representatives:

R. E. Cordray
T. R. Halman
W. A. Lewis
W. E. Marter
W. K. Sonneman

Switchgear Committee Representatives:

J. M. Geiger
K. J. C. Falck
H. Bany
C. A. Woods

Instruments and Measurements Committee Representatives:

J. H. Chiles
A. B. Craig
L. M. Limpus
F. B. Silsbee

Transmission and Distribution Committee Representatives:

J. B. Hodtum
L. M. Moore

Carrier-Current Committee Representative:

L. F. Kennedy

Working Group Chairmen:

W. E. Marter, relaying performance of current transformers
E. C. Wentz, test code
L. F. Kennedy, rating factors

2. Working Groups on Co-ordinated Study of Life of Transformer Insulation

V. M. Montsinger, *chairman*

3. Working Group on Temperature Gradients and Hot Spot Temperatures for Dry-Type Transformers

W. C. Sealey, *chairman*

4. Working Group on Routine Measurement of Hot Spot Temperature Rise

W. C. Sealey, *chairman*

5. Working Group on Accuracy of Voltage Regulator Control Devices

A. A. Johnson, *chairman*

6. Working Group on Operating Guides for Regulators

A. A. Johnson, *chairman*

7. Working Group on Short-Circuit Thermal Ratings of Induction and Step-Type Regulators

A. A. Johnson, *chairman*

8. Working Group on Exciting Currents and Air Break Switches

(*Personnel not yet appointed*)

9. Working Group on Revision of Dielectric Tests

F. J. Vogel, *chairman*

10. Working Group on Temperature Limits of Silicone Insulation Used in Transformers

V. M. Montsinger, *chairman*

11. Working Group on Proposed Revision of ASA Rules in Connection with Short-Circuit Requirements of Transformers

V. M. Montsinger, *chairman*

Transmission and Distribution Committee

1. Capacitor Subcommittee

F. V. Smith, *chairman*
M. I. Alimansky
G. Appleman
C. E. Baugh
E. W. Dillard
R. H. Earle
K. E. Hapgood
E. R. Hendrickson
R. E. Marbury
N. A. Miller
R. B. Miller
C. E. Parks
W. L. Steinbarge
L. T. Williams

Projects:

(*a*). Revision of Standard *C55* (1934) of capacitors.
(*b*). Report on operating practice—fusing practice, circuit characteristics, grounding of neutral, telephone switching, and so forth, in an operating guide.
E. R. Hendrickson, *chairman*
(*c*). Study of troubles with capacitors.
C. E. Parks, *chairman*

2. Distribution Subcommittee

Harold Cole, *chairman*
D. K. Blake
T. J. Brosnan
E. R. Hendrickson
J. B. Hodtum
D. W. Nethercut
E. W. Oesterreich
J. S. Parsons
R. R. Robinson
F. E. Sanford

Projects:

(*a*). Joint working group with transmission systems.
T. J. Brosnan E. R. Hendrickson J. S. Parsons
(*b*). Working group on primary systems.
D. K. Blake L. M. Robertson F. E. Sanford
(*c*). Distribution transformers to the customer.

3. General Systems Subcommittee

S. B. Crary, *chairman*
O. A. Demuth
L. B. Le Vescont
R. G. Hooke
E. K. Huntington
A. A. Kroneberg
E. L. McClure
L. M. Robertson
H. M. Trueblood
R. L. Witzke

Projects:

(*a*). Subject committee on line outages (joint with EEI).
R. W. Caswell
G. D. Floyd
K. W. Hapgood
M. H. Pratt (*for EEI*)
H. M. Trueblood
R. L. Witzke
(*b*). Report on power system overvoltages.
(*c*). Frequency changeover.
(*d*). Contamination and life of insulators.

4. Lightning and Insulator Subcommittee

J. T. Lusignan, *chairman*
H. N. Ekvall
H. A. Frey
I. W. Gross
E. L. Harder
W. W. Lewis
G. D. McMann
S. K. Waldorf
E. R. Whitehead

Projects:

(*a*). Recommendations for lightningproof lines.
E. R. Whitehead, *chairman*
(*b*). Impulse characteristics of insulators, wood, and air in series.
(*c*). Insulator contamination and corrective measures.
(*d*). Insulator flashover characteristics.

5. Towers, Poles, and Conductors Subcommittee

A. E. Davison, *chairman*
N. K. Barr
C. A. Booker
P. J. Croft
A. L. Duna
E. Hansson
E. L. Kanouse
W. I. Middleton
A. A. Osipovich
J. A. Rawls
A. S. Runciman
E. J. Staubitz
G. W. Stickley

OF CURRENT INTEREST

Student Guidance Committee

Seeks Additional Members

With the completion of ten years of service to high school students contemplating entering the engineering profession, the New York Engineers' Committee on Student Guidance announces expansion of its services to cover greater territory in the metropolitan district. To carry on this additional work, the committee, which is composed of representatives of the American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, the AIEE, and the American Institute of Chemical Engineers, operating under the auspices of the Engineers' Council for Professional Development, is seeking new recruits from the engineering profession. Present committee personnel stands at about 80, but it is necessary to increase this number if the expanded service is to be maintained successfully. The committee originally served high schools of New York City only.

The low percentage of freshmen finally graduating from engineering schools motivated the formation of the student guidance committee. Its principal aim is to provide information for students about the engineering profession, thus enabling them better to evaluate their aptitudes and inclinations. The committee definitely avoids "selling" the profession to students; it is especially anxious to advise students who do not possess the needed basic aptitudes to prepare themselves for work other than engineering. As many as five committee members may make any one visit, which consists of presenting short talks on the engineering profession as a whole, specialties of each branch, how an engineer is trained, and the personal requirements and aptitudes needed to be an engineer. These visits feature a period in which students ask questions of the committee members which usually range over many aspects of the subject. Each meeting terminates with a consultation period in which any student may ask questions concerning personal guidance of any of the committee members in private.

In preparation for the projected expansion of service, the executive committee has been enlarged to include three vice-chairmen whose principal function will be to act as liaison officers for the committee with high schools in three areas of the metropolitan district. For 1947–48 the following men have been selected:

1st vice-chairman: R. L. Taylor (AIChE) *Chemical Industries*, New York, N. Y.—*New York City area*

2d vice-chairman: H. F. Roemmele (ASME) Cooper Union School of Engineering, New York, N. Y.—*Westchester County area*

3d vice-chairman: J. M. Comly (M'36, AIEE) Consolidated Edison Company of New York, Inc., New York, N. Y.—*Long Island area*

Other officers for the current year are

Chairman: A. T. Glassett (ASCE) W. J. Barney Corporation, New York, N. Y.

Secretary: B. G. A. Skrotzki (M'45, representing ASME) *Power*, New York, N. Y.

Treasurer: S. P. Wimpfen (AIME) *Mining and Metallurgy*, New York, N. Y.

AIEE members interested in participating in the work of the New York Engineers' Committee on Student Guidance are urged to contact the AIEE subcommittee chairman, S. P. Shackelton, Bell Telephone Laboratories, 463 West Street, New York, N. Y.

Washington Modernizes

Its Engineers' Registration Act

The Professional Engineers' Registration Act of the State of Washington was revised during the 1947 legislative session. This was the first change made in the engineers' registration act since the law first was passed in 1935.

The original registration law licensed only three major branches of engineering, electrical, mechanical, and civil, as well as two civil engineering subdivisions, structural and hydraulic. Since that law was enacted, the model law for the registration of engineers has been endorsed by the AIEE and other national engineering societies. The model law contains several features which it was desirable to adopt, the principle one being the certification of engineers-in-training.

SPONSOR OF LAW

The new law was sponsored by the Puget Sound Engineering Council which the Seattle Section of the AIEE led in the organization of in 1944. This year several engineering societies including mining, chemical, logging, and others expressed the desire to be taken in under the old law and petitioned the council, composed of 20 engineering and technical societies covering the western part of Washington, to prepare and sponsor the necessary revisions of the old law.

The council secured the necessary legal advice to assist it in preparing a draft of a new law. The draft was submitted to council member societies and to engineering societies in Spokane for comments and suggestions. A final draft then was prepared and sent to all engineering societies throughout the state asking their support. Letters of endorsement were furnished by most of the societies to the council so that when the bill was introduced it carried with it the overwhelming endorsement of the entire engineering profession of the state.

The new law authorizes the practice of "professional engineering" and the certificates specify the branch in which specialized. However, the law does not name the recognized branches of engineering, leaving that to the board. The law retains a 5-man board, specifies a 5-year term, requires 12 years' engineering experience, and provides $25 per day compensation. The engineers' registration qualification is eight years' experience, four of which may be college graduation. The engineers' registration fee is $25, $15 of which accompanies application and $10 is paid upon issuance of license. The fee for an engineer-in-training certificate is $10 and $15 is paid upon qualification as a professional engineer. The yearly renewal fee for the license is $5. The act includes the usual reciprocity and exemption classes and provides for licensing of practitioners at time of act, not including those branches which are covered by the original act.

ENGINEERS RESPONSIBLE

Three engineers were mainly responsible for the writing and passage of the act. R. E. Kistler, chairman of the Puget Sound Engineering Council and past chairman of the Seattle Section of the AIEE directed the preparation of the bill and co-ordinated the support for its passage. W. D. Shannon, representative of the 43d district and vice-president of the American Society of Civil Engineers, introduced the bill into the legislature and followed it through both houses. E. C. Dohm, of the ASCE, who since has been made executive secretary of the Engineers' Board, furnished the board's help and secured administration approval of the bill. Many other engineers from all branches testified before committees and secured legislative support when the bill came to a vote.

The new Engineers' Registration Act is known as "Chapter 283 of the Laws of 1947," of the State of Washington. Copies of the act may be secured by writing to E. C. Dohm, Executive Secretary, Board of Engineers, Department of Licenses, Olympia, Wash.

“Production for Peace” Sets Pace for 1947 Annual Meeting of ASME

With “production for peace” as its keynote, the 68th annual meeting of the American Society of Mechanical Engineers was held in Atlantic City, N. J., December 1–5, 1947. The onward march of industry toward new and better products, more efficient methods, and greater economy of production, and the engineers’ part in that progress, was the subject of many of the 80 technical sessions which featured some 240 authors and speakers. This 68th meeting of the ASME presented a marked contrast to the group of a few hundred engineers who constituted the membership nearly seven decades ago, when the society was formed. ASME membership now stands at more than 23,000.

SUBJECTS COVERED

The field of nuclear energy was represented by an address by David C. Lilienthal, chairman of the United States Atomic Energy Commission, on “Atomic Energy and the Engineer.” In this connection, under the auspices of the Commission an exhibit illustrating the principles of nuclear energy was shown for the first time by the Brookhaven National Laboratory.

A warning that the United States immediately must start building a synthetic liquid fuels industry, not delaying until an “emergency period,” was issued by W. C. Schroeder of the Bureau of Mines, before a technical group, and wood industries men were shown how chemistry is being employed to increase the efficiency of water in fighting forest fires. Stress was placed also on the recent uses of laminates.

In the plastics and rubber field, progress reports were given, and a new synthetic silicone rubber with high temperature resistant qualities was described. It was pointed out that plastic tooling, already used in the aviation industry, has a place in other industries. In the field of medicine, plastics are being used in treating stomach ulcers.

Aviation was the subject of several sessions, cosponsored by the American Rocket Society, in which developments in rocketry were stressed. For process industries men, the problem of the pollution of American streams and rivers by industrial wastes, how it can be met, and how it is being met in the state of Pennsylvania, was described. Applied mechanics and heat transfer engineers heard a report on an industrial survey completed by an ASME research group on the properties of gases.

Other sessions at the ASME meeting dealt with metals engineering, machine design, hydraulics, safety, industrial instruments and regulators, materials handling, oil and gas power, petroleum, education, and citizenship.

HONORS

During its 1947 annual meeting, the ASME presented a number of awards and honors for distinguished work in engineering and other fields. Honorary memberships were conferred on:

Doctor Harvey N. Davis, president, Stevens Institute of Technology, Hoboken, N. J., for his “distinguished career as scientist, engineer, and educator.”

Doctor Francis Hodgkinson (A ’02) honorary professor of mechanical engineering, Columbia University, New York, N. Y., and retired consulting engineer of the Westinghouse Electric Corporation, for his pioneer work and “outstanding achievement in the development of the steam turbine prime mover.”

Everett G. Ackart, chief engineer, E. I. duPont de Nemours and Company, Wilmington, Del., from 1927 to 1946, for “a successful career of 40 years in designing industrial steam plants.”

George C. Marshall, Secretary of State, honored in absentia for his “distinguished services in military science and as Chief of Staff and General of the Army during the war, and as Secretary of State.”

Among the medals awarded at the meeting were the following:

The ASME Medal, the society’s highest award, to Paul W. Kiefer, New York Central Railroad, New York, N. Y., for “outstanding achievement in railway transportation.”

The Holley Medal to Raymond D. Johnson, Fort Lauderdale, Fla., “pioneer in hydraulic engineering, master of fluid acceleration, accelerator of engineering progress.”

The Warner Medal to Arpad L. Nadai, Westinghouse Research Laboratories, East Pittsburgh, Pa., for “pioneer contributions to the theory of plasticity.”

The Gantt Medal, a joint presentation with the Institute of Management, to Alvin E. Dodd, president, American Management Association, New York, N. Y., “for his leadership in stimulating greater recognition and acceptance of the social responsibilities of management; and for his success in building the American Management Association into an authoritative forum for collecting, analyzing, and disseminating management knowledge.”

Technical and Scientific Center Established for Chicago

Creation of a Chicago technical and scientific center through an alliance between the Western Society of Engineers and the John Crerar Library was formalized on December 3, 1947, with the signing of an agreement between the two organizations. The agreement covers the leasing by the Western Society of three floors in the Taylor Building, in Chicago, Ill., which is owned by the library, and the establishment by the engineering group of a science and technical center for the use of professional persons, students, and others interested in the advancement of science.

Offices, conference rooms, and an auditorium with a seating capacity of 300 will be included in the center, which will cover over 9,000 square feet of floor space. Eventually it is expected that other groups having comparable objectives and professional standards as the Western Society of Engineers will participate in the scientific and technical center program.

The library of the Western Society, a collection of more than 20,000 books and pamphlets, will be co-ordinated with the 700,000-volume Crerar Library, the world’s largest free public library devoted exclusively to science and technology. The engineering society expects to make a capital expenditure of about $100,000 to develop the new science center.

Founded in 1869, the Western Society of Engineers is a professional organization representing all branches of engineering in Chicago and the Central West. Through its various committees, members of the society have taken an active part in such civic and community developments of an engineering nature as traffic controls, airport facilities, railroad terminals, slum clearance, building code modernization, and related problems.

The John Crerar Library, which was opened in 1895, has been recognized as a major force in the development of Chicago as a great center for science and industry. The library recently inaugurated a program of expanded public services known as the Research Information Service to make its vast accumulation of knowledge more readily available.

Applied Mechanics Congress to Be Held in London in 1948

An invitation has been extended to American engineers and scientists to attend the Seventh International Congress of Applied Mechanics to be held at the Imperial College of Science and Technology, South Kensington, London, England, September 5–11, 1948.

The technical sessions will be organized under the following sections:

1. Elasticity and plasticity.
2. Aerodynamics, hydrodynamics, meteorology.
3. Thermodynamics, heat transfer, and so forth.
4. Vibrations, lubrication, and experimental methods.

In addition, as many as ten general lectures or surveys are contemplated on subjects likely to be of interest to members.

Members whose papers are accepted for presentation should provide copies of abstracts for the information of other members. These should be in the hands of the organizing secretary of the congress as early as possible. The Imperial College has no facilities for reproduction of abstracts of papers.

The registration of approximately $5 may be paid at the time of registration or in advance to the organizing secretary at Imperial College.

During the week following the congress, inspection trips are being planned to the National Physical Laboratory, the Royal Aircraft Establishment, the National Gas Turbine Establishment, and the General Electric Research Laboratories.

The organizing committee of the congress is compiling a list of hotels in the neighborhood of the congress and engineers planning to attend should get in touch with the organizing committee as soon as possible. For the best hotel accommodations, reservations should be made early in 1948. They can be made through the organizing secretary at Imperial College.

Midget X-Ray Tube Developed for Dental Use

A dental X-ray tube no larger than a power tube in a home radio set has been developed by Westinghouse Electric Corporation, Bloomfield, N. J. The new tube has operated steadily on test for 1,000 hours, the equivalent of 20 years of normal usage in a dentist's office.

One of the smallest X-ray tubes ever offered commercially, the new design minimizes stray radiation through the use of a copper hood that shields the tube's tungsten electrode. The hooded design serves as an equipotential shield that reduces the possibility of damaging cathode bombardment to a minimum when the focal spot is overloaded. Such overloading will bring the cathode to electron emitting temperatures. As a result, a flood of electrons will be released that will cause irreparable damage to the tube. The hood also serves as a grid that tends to block back discharge in case of moderate overloads.

As the electrons bombard the target, X rays are beamed through a tiny porthole in the hood onto the film through a window in the glass tube about the size of a dime. This window, made of special hard glass that transmits X rays, is ground down to a uniform thickness of about 20-thousandths of an inch for all tubes, assuring the radiographer of consistent exposures. Previously, tube windows had to be made thicker as a protection against unused electrical charges released within the tube. As a result, more than ten per cent of the useful X rays were lost.

Engineering Progress Show to Be Held in Philadelphia

The Engineers' Club of Philadelphia Junior Members are joining with the Franklin Institute of the State of Pennsylvania in sponsoring a second Engineering Progress Show, May 11–16, 1948. Exhibits will include many items depicting the progress in engineering. The first show held in the spring of 1947 was highly successful, having an attendance record of over 10,000, and booths sold out to exhibitors in advance of the show date.

The show will be held in Franklin Hall in the Franklin Institute of Pennsylvania. In addition to the exhibits, two nationally prominent engineers will deliver lectures in the Franklin auditorium on two evenings during the week.

Safety Committee Formed. The need for better organized safety efforts drew together representatives of radio and electric equipment manufacturing firms throughout the United States at the recent National Safety Congress, sponsored by the National Safety Council. The outcome was the formation of a Radio and Electric Equipment Manufacturers' Committee, with a view toward developing another permanent section of the National Safety Council for industry-wide study and attack on accident problems. Elected as officers of this committee were: *chairman*, E. K. Taylor, Zenith Radio Corporation, Chicago, Ill.; *vice-chairman* (*radio and electronics division*), O. C. Boileau, Radio Corporation of America, Camden, N. J.; *vice-chairman* (*heavy apparatus division*), H. B. Duffus, Westinghouse Electric Corporation, Pittsburgh, Pa.; *vice-chairman* (*light apparatus division*), M. F. Biancardi, Allis-Chalmers Company, Milwaukee, Wis.; *vice-chairman* (*appliances and lamps division*), C. R. DeReamer, General Electric Company, Schenectady, N. Y.; *Newsletter editor*, C. E. Woodward, A. O. Smith Corporation, Milwaukee, Wis.; *subcommittee chairman* (*scopes committee*), J. M. Transue, Philco Corporation, Philadelphia, Pa.; *secretary*, G. W. Greenwood, Western Electric Company, Chicago, Ill.

NRC Engineering Division Officers. The Division of Engineering and Industrial Research of the National Research Council has completed its organization for the year 1947–48 and announced as its newly appointed vice-chairman, Doctor Harold K. Work, manager, research and development, Jones and Laughlin Steel Corporation, Pittsburgh, Pa. Newly appointed members of the division, representing the engineering section of the National Academy of Sciences, are Gano Dunn (F'12, HM'45), C. Richard Soderberg, and C. G. Suits (F'47); representing national technical societies, George O. Curme, Jr. (American Institute of Chemical Engineers), H. C. Dickinson (Society of Automotive Engineers), and Walter C. Voss (American Society for Testing Materials); and as new representatives of the Government, E. U. Condon (M'44, National Bureau of Standards) and W. E. Reynolds (Public Buildings Administration). The three new members-at-large are Lyman J. Briggs, formerly director, National Bureau of Standards, J. E. Hobson (M'41) director of Armour Research Foundation, and C. E. MacQuigg, dean of engineering, Ohio State University.

Pan-American Engineering Congress Announced

United States engineers will join with engineers of South America in a Pan-American Engineering Congress, to be held in South America late in 1948 or in 1949, according to the Engineers' Joint Council committee on international relations. Canadian engineers also will be invited to participate, through the Engineering Institute of Canada.

Dean S. S. Steinberg, of the University of Maryland, Baltimore, Md., chairman of the commission on Latin America of the committee on international relations, who has spent much time in contact with South American engineers, stressed their great desire for such a western hemisphere congress, and the mutual benefits that would accrue to all countries taking part. Bogota, Colombia, has been suggested as the place for the first congress.

Participation will be recommended to all constituent societies of the Engineers Joint Council. These include AIEE, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and American Institute of Chemical Engineers.

Newspaper Television Station. The RCA Victor division of the Radio Corporation of America has contracted to build a 5-kw television transmitter and associated pickup and relay equipment for New York's first newspaper-owned television station, to be operated by the News Syndicate Company, Inc., publishers of the New York *Daily News*. The television station, to which the Federal Communications Commission has assigned the call letters *WLTV*, will be located in the *Daily News* Building in New York City and will operate in channel 11 (198–204 megacycles). The station is expected to go on the air with test patterns early next spring.

W. A. Buttrick Dies. William A. Buttrick, 72, who served as president of Central Vermont Public Service Corporation from its organization in 1929 until his retirement in April 1936, died suddenly at his home in Concord, Mass., Friday morning, November 21, 1947. Mr. Buttrick served as president of both the Central Vermont Public Service Corporation and the Twin State Gas and Electric company, from 1929 until his retirement in 1936. He was one time director of New England Public Service company and the Public Service Company of New Hampshire. He is survived by his wife, Mrs. Madge Buttrick, and a stepdaughter.

University of Illinois Offers Assistantships and Fellowships

The department of electrical engineering at the University of Illinois, Urbana, Ill., will have openings for both graduate teaching assistants and research assistants. These assistantships are open to electrical engineering graduates with excellent records. Applications should be made not later than March 15, 1948.

A number of fellowships also are available, for students who expect to take graduate work in electrical engineering. These include the following, with the stipend for an academic year: Jansky and Bailey, $750; Motorola, Inc., $750; Westinghouse Educational Foundation, $1,000; and the University of Illinois, $500 and $900.

Application for these fellowships may be made by writing to the dean of the graduate college, University of Illinois. The closing date for fellowship applications is February 15, 1948.

GM Exhibit. An industrial exhibit, designed and built by General Motors Corporation to portray graphically the 50-year story of the development of the automobile, has been opened to the public at the Chicago Museum of Science and Industry, Chicago, Ill. The exhibit, which has been named the Motorama, has eight major sections, each telling a part of the broad history involved in the development of the automobile. These sections, in turn, are subdivided into 78 separate units which give a more detailed picture. The entire display is linked together on a natural time basis, moving from the earliest means of transport to the present day. The exhibit occupies a large section of the main floor of the museum, with more than 10,000 square feet of floor space in which some 1,100 lineal feet of exhibits and displays have been assembled.

OTHER SOCIETIES •

New Scientific Monthly Reviews Applied Mechanics

The first issue of *Applied Mechanics Reviews*, a new monthly engineering and scientific journal devoted to reviewing current world-wide literature in the field of applied mechanics, is scheduled to appear in January 1948. Cosponsors are the American Institute of Mechanical Engineers, the Engineering Foundation, the Illinois Institute of Technology, and other organizations. The business address is the Engineering Societies Building, 29 West 39th Street, New York 18, N. Y.

Editorial policy will be under the general supervision of a committee representing the ASME, the Office of Naval Research, the American Institute of Physics, the American Society of Civil Engineers, the Institute of Aeronautical Sciences, the American Mathematical Society, the Society for Experimental Stress Analysis; also the Institution of Mechanical Engineers of Great Britain and the Engineering Institute of Canada.

Doctor L. H. Donnell, research professor of mechanics at the Illinois Institute of Technology, Chicago, Ill., has been appointed editor-in-chief. Doctor S. P. Timoshenko, of Palo Alto, Calif., professor emeritus of Stanford University, who is internationally recognized as the dean of applied mechanics studies, will be editorial adviser.

To insure world-wide coverage, the editorial board of *Applied Mechanics Reviews* will cull the output of some 500 engineering and scientific journals here and abroad, selecting those of greatest significance. About 200 signed reviews, written by authorities in the respective fields, are planned for each issue, of some 40 pages. Bibliographies will be included.

Reviews, each about 500 words long, will deal with important theoretical and experimental papers on solid mechanics, fluid mechanics, thermodynamics, and heat transfer, as well as applications of these to geophysics, and to such specialized subjects as soil mechanics, acoustics, ballistics and lubrication.

Future Meetings of Other Societies

American Institute of Mining and Metallurgical Engineers. Annual meeting, February 15–19, 1948, New York, N. Y.

American Iron and Steel Institute. May 26–27, 1948, New York, N. Y.

American Society of Civil Engineers. Annual meeting, January 21–24, 1948, New York, N. Y.; spring meeting, April 7–9, 1948, Pittsburgh, Pa.; summer convention, July 21–23, 1948, Seattle, Wash.

American Society for Engineering Education. June 14–18, 1948, Austin, Tex.

American Society of Heating and Ventilating Engineers. February 2–5, 1948, New York, N. Y.

American Society for Testing Materials. Spring meeting and committee week, March 1–5, 1948, Washington, D. C.; annual meeting, June 21–25, 1948, Detroit, Mich.

American Society of Tool Engineers. Sixth annual industrial exposition, March 15–19, 1948, Cleveland, Ohio.

Canadian Institute of Radio Engineers. Convention, April 30–May 1, 1948, Toronto, Ontario, Canada.

CIGRE (International Conference on Large Electric High-Tension Systems). Biennial meeting, June 24–July 3, 1948, Paris, France.

Edison Electric Institute. Annual engineering meetings, May 3–5, 1948, Chicago, Ill.; annual convention, June 2–4, 1948, Atlantic City, N. J.

Institute of Radio Engineers. Annual convention and radio engineering show, March 22–25, 1948, New York, N. Y.

Midwest Power Conference. Annual meeting, sponsored by Illinois Institute of Technology, April 7–9, 1948, Chicago, Ill.

Minnesota Federation of Engineering Societies. 26th annual engineering convention and 3d annual engineering exposition, February 11–14, 1948, St. Paul, Minn.

National Academy of Sciences. April 26–28, 1948, Washington, D. C.

National Association of Broadcasters. 26th annual convention, week of May 17, 1948, Los Angeles, Calif.

National District Heating Association. 39th annual meeting, May 18–21, 1948, St. Louis, Mo.

National Electrical Manufacturers Association. Winter convention, March 14–18, 1948, Chicago, Ill.

National Electrical Wholesalers Association. 39th annual convention, May 2–7, 1948, Buffalo, N. Y.

National Materials Handling Exposition. January 12–16, 1948, Cleveland, Ohio.

Refrigeration Equipment Manufacturers Association. All-Industry Refrigerating and Air-Conditioning Exposition, January 26–29, 1948, Cleveland, Ohio.

Society of Automotive Engineers. January 12–16, 1948, Detroit, Mich.

Southern Machinery and Metals Exposition. Third exposition, April 5–8, 1948, Atlanta, Ga.

Minnesota Engineering Convention. The 15 members of the Minnesota Federation of Engineering Societies will stage their 26th annual engineering convention and third annual engineering exposition, February 11–14, 1948, in St. Paul, Minn. Luncheons, business sessions, symposiums, technical discussions, dinners, and talks by state and national figures have been booked for the convention in Hotel Lowry, and exhibitors are preparing engineered products and devices for exhibition in the Municipal Auditorium. The exposition, open to the public, is expected to draw 100,000 spectators. Further information may be obtained from the Federation secretary, Katherine A. Feucht, 1000 Guardian Building, St. Paul, Minn.

ASCE Establishes New Annual Award

A new annual award in honor of the late James W. Rickey, former hydroelectric engineer with the Aluminum Company of America, has been announced by the American Society of Civil Engineers. The organization has accepted the offer of Mrs. Lucy M. Rickey, Washington, D. C., to establish a sum of $16,500 to perpetuate the memory of her late husband.

The award, to be known as the Rickey Medal, will be a gold medal and an engraved certificate. It will be made for papers in the general field of hydroelectric engineering, including any of its branches, deemed to constitute an outstanding contribution to the art, with consideration both for the usefulness of the subject matter and the form of presentation in ASCE "Transactions." The award will be open to nonmembers, as well as members of the ASCE.

Mr. Rickey, who retired January 1, 1938, after eminent professional accomplishments in the field of hydroelectric engineering, had been active in the ASCE since 1902, and had been an officer of the society's power division, whose executive committee each year will judge the papers for eligibility for the medal.

New AIME Officers. The election of William Embry Wrather as president of the American Institute of Mining and Metallurgical Engineers for 1948 was announced recently. Doctor Wrather is director of the United States Geological Survey, Washington, D. C. Also elected were two new vice-presidents: C. Harry Benedict, Calumet and Hecla Consolidated Copper Company, Lake Linden, Mich., and Donald H. McLaughlin, president, Homestake Mining Company, San Francisco, Calif.; five new directors; and six new directors ex-officiis who will serve as chairmen of the professional divisions of the institute.

NEMA Announces Names of New Officers

William C. Johnson, executive vice-president in charge of the general machinery division of Allis-Chalmers Manufacturing Company, Milwaukee, Wis., is the new president of the National Electrical Manufacturers Association. He succeeds

R. Stafford Edwards, president of Edwards and Company, Inc., Norwalk, Conn. Mr. Johnson has served NEMA as a member of its board of governors and as a vice-president since 1944. He also is a director of the National Industrial Conference board.

Three new members of NEMA's board of governors are J. H. Ashbaugh, vice-president of Westinghouse Electric Corporation, Mansfield, Ohio; D. F. G. Eliot, vice-president, Western Electric Company, Inc., New York, N. Y.; and J. J. Nance, president of Hotpoint, Inc., Chicago, Ill.

B. W. Clark, vice-president of the Westinghouse Electric Corporation, Pittsburgh, Pa., and Whipple Jacobs, president of the Belden Manufacturing Company, are two new NEMA vice-presidents.

E. E. Potter, vice-president, General Electric Company, New York, N. Y., has been elected treasurer.

HONORS

Nichols Medal Won by G. T. Seaborg

Professor Glenn T. Seaborg of the University of California, Berkeley, Calif., codiscoverer of plutonium, man-made source of atomic energy, has been awarded the William H. Nichols Medal of the New York section of the American Chemical Society for 1948.

The medal, one of the highest honors in chemical science, goes to Professor Seaborg for his research on plutonium, element 94, and his participation in the discovery of americium and curium, elements 95 and 96, and numerous artificial radioactive materials.

Professor Seaborg, 35 years old, is a member of the 9-man advisory committee appointed by President Truman to assist the United States Atomic Energy Commission. He received the $1,000 ACS prize in pure chemistry at the society's recent national meeting in New York for his contributions to nuclear science. In 1946 he was chosen "Chemist of the Year" in a nation-wide poll of chemists and chemical engineers conducted by *Chemical and Engineering News*, publication of the society.

The citation accompanying the Nichols award to Professor Seaborg reads "Codiscoverer of numerous artificially produced radioactive isotopes and the elements plutonium, americium, and curium. Responsible for the determination of the fissionability of plutonium and other heavy isotopes and major contributors to chemical processes for the production of plutonium. Propounder of the idea of the actinide series for the transuranium elements."

A native of Ispheming, Mich., Professor Seaborg received the bachelor of arts degree from the University of California at Los Angeles in 1934 and the doctor of philosophy degree from the University of California, Berkeley, in 1937. After two years as a research associate in chemistry, he became an instructor in 1939 and rose to the rank of full professor in six years.

During the war, on a leave-of-absence from California, he directed chemical research on plutonium and other heavy elements for the atomic bomb project at the University of Chicago metallurgical laboratory. He received the 1945 Distinguished Service Award of the Chicago Junior Association of Commerce, and in 1946 was chosen Harrison Howe Lecturer by the Rochester section of ACS, and was elected a councilor-at-large of the society. He was appointed consultant in nucleonics at the General Electric Company research laboratory in Schenectady, N. Y., this year.

The Nichols Medal award, conferred annually to stimulate original research in chemistry, was founded by the late Doctor William H. Nichols, a charter member of ACS and chairman of the board of the Allied Chemical and Dye Corporation. Presentation of the medal to Professor Seaborg will be made on March 5, 1948, at a joint meeting of the society's New York section and the American section of the Society of Chemical Industry at the Hotel Pennsylvania in New York, N. Y.

AMA President Wins ASME Management Award

The American Society of Mechanical Engineers has announced the award of the 1947 Gantt Memorial Medal for "distinguished achievement in industrial management as a service to the community" to Alvin E. Dodd, president of the American Management Association, for "his leadership in stimulating greater recognition and acceptance of the social responsibilities of management and for his success in building the American Management Association into an authoritative forum for collecting, analyzing, and disseminating management knowledge."

Awarded each year since 1929 to commemorate the achievements of Henry Laurence Gantt, pioneer management engineer and industrial leader, the medal was presented on December 4, 1947, during the yearly meeting of the ASME at Atlantic City, N. J.

As president of the American Management Association, Mr. Dodd is chief executive of an organization of more than 11,000 individuals and companies representing virtually all the nation's businesses and industries. Under his supervision the AMA is a clearing house of management information and experience through periodic national conferences on management problems, publication of management literature, maintenance of research and information services, and the world's largest management library.

Through the personnel, production, finance, insurance, marketing, packaging and office management divisions which are AMA's principal operating components, he is active in all phases of American management. Active in the international management movement through membership in the national management council and work with the international committee for scientific management, he served recently as an American delegate to the Eighth International Management Congress in Sweden.

He is also vice-president of the National Institute of Social Sciences, a member of the economic policy committee of the United States Chamber of Commerce, and of the information committee of the committee for economic development.

ASCE Award Aids Army Engineer's Project

An award of $800 from its Freeman Fund to Lieutenant Colonel George F. Dixon, Corps of Engineers, now taking postgraduate work at Cornell University, for a study of European installations to maintain harbor channel depths by induced scouring, has been announced by the American Society of Civil Engineers.

Assigned to European duty by the Corps of Engineers, Colonel Dixon's research will be aided from the fund created in 1924 for the encouragement of young engineers in the study of hydraulics. Titled, "Investigation of European Method of Harbor Channel Control by the Use of Regulatory Works," Colonel Dixon's project is aimed at study of methods employed at Bremerhaven, Bremen, Rouen, Havre, and Ostend.

United States harbor channels require $25,000,000 of dredging work annually by the Corps of Engineers, and Colonel Dixon's project will be a study on possible savings that may be effected. In his work, he will do research at the Technical University at Karlsruhe and the Berlin experimental establishment for hydraulic engineering and ship building.

This is the first time since 1940 that an award has been made from the $25,000 fund established by the late John R. Freeman, past-president and honorary member of the society. Interest from the fund is used to underwrite projects such as that being undertaken by Colonel Dixon.

Materials and Methods Achievement Awards

Doctor Cledo Brunetti, chief of the engineering electronics section of the National Bureau of Standards, Department of Commerce, Washington, D. C., just has been chosen as the 1947 recipient of the Materials and Methods Achievement award conferred annually by the editors of *Materials and Methods* magazine, New York, N. Y., for outstanding current work in the application, processing, or development of engineering materials. An independent group of judges appointed by the magazine made the selection along with several special awards and honorable mentions.

Doctor Brunetti received the grand award "for the most significant use of modern engineering materials and processing methods to increase production and reduce the cost of products now being manufactured," according to the award citation. His specific achievement was the development of an ingenious system of printing rather than wiring electronic circuits, utilizing extremely compact ceramic, plastics, or other nonmetallic plates printed with silver ink.

Special awards were made to Latrobe Electric Steel Company, Latrobe, Pa., for the development of high speed tool steels free from the metallurgical segregation often found in such steels, and jointly to Republic Steel Corporation of Cleveland, Ohio, and Arthur D. Little Company of Cambridge, Mass., for their development of a process for operating pig iron blast furnaces at high pressures, with consequently greatly reduced manufacturing cost of this basic raw material.

Honorable mentions for other recent materials-and-processing developments went to C. G. Peters and associates at the National Bureau of Standards, Washington, D. C., for a new electrical process for drilling diamond dies; Thermex division of the Girdler Corporation, Louisville, Ky., for the application of high-frequency heating to the edge-bonding of wood panels; Westinghouse Electric Corporation, motor division, Buffalo, N. Y., for a new materials-and-processing approach in the manufacture of electric motors; Rigid-Tex Corporation, Buffalo, N. Y., for the development of design-strengthened surface-patterned sheet metal products; and T. E. Eagan, Cooper-Bessemer Corporation, Grove City, Pa., for the successful use of cast iron for Diesel engine crankshafts.

NEMA Honors. Five members of the National Electrical Manufacturers Association have been honored for outstanding contributions to the electrical manufacturing industry. NEMA gold certificates, in recognition of 50 or more of continuous service, were presented to these electrical pioneers:

Clarence L. Collens (M '40) chairman of the board, The Reliance Electric and Engineering Company, Cleveland, Ohio; F. P. Fuller, vice-president, Graphite Metallizing Corporation, Yonkers, N. Y.; Wilbur F. Hurlburt, president, Automatic Switch Company, New York, N. Y.; Joseph S. Thompson (F '38) president, Pacific Electric Manufacturing Corporation, San Francisco, Calif.; and A. H. Timmerman (F '12) vice-president, Wagner Electric Corporation, St. Louis, Mo.

Eugene Grace Awarded Charles F. Rand Medal

Eugene Gifford Grace, chairman of the board, Bethlehem Steel Corporation, has been awarded the Charles F. Rand Gold Medal of the American Institute of Mining and Metallurgical Engineers for "distinguished achievement in mining administration." Doctor Grace was selected by unanimous vote of the AIME board of directors to receive the award which will be presented at the society's annual meeting in New York, N. Y., in February 1948.

Widely known as a steel manufacturer and administrator, Doctor Grace, who holds the degrees of electrical engineer and doctor of engineering from Lehigh University, has been associated with the Bethlehem Steel Corporation since 1899. In his first position for the company he was put in charge of an electric crane and the intervening half century has seen his progressive advancement which culminated in 1945 in his present position as chairman of the board.

His nomination for the gold medal was accompanied by the following citation:

For distinguished leadership in the administration of all phases of a large and complex industrial enterprise; for profound influence on the growth and health of the American iron and steel industry.

John Fritz Medal to von Karman. The John Fritz Medal for 1948, "highest award in engineering," has been awarded to Doctor Theodor von Karman as a "creative leader, stimulating teacher, and wise counselor in engineering and physical research in the fields of the aeronautical and structural sciences, for his many applications of mathematical and physical theory to the sound solution of engineering problems." The John Fritz Medal, established in 1902 by the national professional societies of civil, mining and metallurgical, mechanical, and electrical engineers, is given for notable scientific or industrial achievement, and is international in scope.

Merit Awards Presented at Lighting Exposition

Announcement of 200 winners of Gold Seal and Merit Award Certificates was a feature of the opening session of the second International Lighting Exposition and Conference in Chicago, Ill. Many of the winners were present to receive the awards, totalling $1,200 in Gold Seal Awards, and 183 Merit Award Certificates. In the winning Gold Seal group were six store lighting installations, one office, one floodlighting, two industrial, one bank, and one restaurant. All of the winning entries were on display at the exposition. The competition was sponsored by the industrial and commercial lighting equipment section of the National Electrical Manufacturers Association.

GOLD SEAL MERIT AWARD WINNERS

Announced as winners of Gold Seal $100 Awards were:

Architects and consulting engineers—J. L. Phillips, Birmingham, Ala. (office lighting); F. D. Wyatt, Chicago, Ill. (floodlighting); Harold W. Goetz, Cincinnati, Ohio, jointly with utility lighting representative, Robert W. Brown, Cincinnati Gas and Electric Company (store lighting).

Electrical contractors—George W. Phelps, Boston, Mass., jointly with wholesaler's lighting representative, Ralph L. Huse, Graybar Electric Company (store lighting); E. J. White, Edward J. White Company, New York, N. Y. (industrial lighting); Spott Electrical Company, Oakland, Calif., jointly with utility lighting representative, Donald R. Keebaugh, Pacific Gas and Electric Company, Oakland, Calif. (store lighting).

Electrical wholesalers' lighting specialists and salesmen—John W. Leadbetter, Koontz-Wagner Electric Company, Inc., South Bend, Ind. (industrial lighting); Fred N. Cooper, John E. Graybill, and Company, Lancaster, Pa. (restaurant); and C. B. Marsh, Jr., Marsh Electric Supply, Amarillo, Tex. (store lighting).

Utility lighting representatives—Jack F. Parsons and William B. Campbell, Buffalo Niagara Electric Corporation, Buffalo, N. Y., for a joint entry on bank lighting; John B. Martin and Lucian T. Kight, Duquesne Light Company, Pittsburgh, Pa., for a joint entry on store lighting; and Ralph W. McClure, Cincinnati Gas and Electric Company, Cincinnati, Ohio, for store lighting installation.

MERIT AWARDS

Also awarded were 183 Merit Award Certificates. In the geographical distribution of these awards, the Middle West led with 78 winners, the East next with 56 winners, the Far West 24, the South 20, the West 5, and Canada, 1. Of the 183 certificates, 21 went to electrical contractors 22 to electrical wholesalers, 18 to architects and consulting engineers, and 122 to utility lighting representatives.

RCA Gets Navy Citation. A citation has been presented to the RCA Victor division of the Radio Corporation of America, Camden, N. J., for services rendered to the United States Naval Reserve in 1947. The citation is signed by James Forrestal, as Secretary of the Navy, and Chief of Naval Operations Admiral Chester W. Nimitz, United States Navy. Three individual citations also have been presented to Frank M. Folsom, executive vice-president in charge of the RCA Victor division; John K. West, director of public relations of the company; and Robert Merrill, Metropolitan Opera star. The citations were presented for the company's outstanding contributions in connection with the Naval Reserve campaign.

RESEARCH • • • •

National Research Council Offers 1948-49 Fellowships

The National Research Council again is offering a number of opportunities for advanced study and research in the natural sciences. Fellowships for the academic year 1948–49 are being announced under a series of programs financed from various sources, but administered under fellowship boards established by the NRC. These are in addition to fellowships in the medical sciences announced separately.

The postdoctoral fellowship program which has been administered by the council over a period of 28 years will continue. This program has been financed by grants from the Rockefeller Foundation since its inception. It is designed to permit young men and women who have demonstrated their ability in research in the natural sciences to spend additional time in uninterrupted study. The program has been of the utmost significance in American science. Many leading scientists of today studied under these fellowships after receiving their doctorates, and went on to gain distinction as leaders of American science.

The candidates applying for fellowships under this program must have completed the requirements for the doctor's degree before entering upon their fellowships. Fields of study embraced by the program include the physical and mathematical sciences, geology and geography, biological and agricultural sciences, anthropology, and psychology. Stipends are at the rate of $2,500 per annum, plus travel to the place of study, although larger stipends may be granted to Fellows with dependents. Appointments are for one year but reappointments for an additional year may be made in some cases. Applications for study abroad have been granted in cases where the additional advantages make it desirable.

Following the late war, Merck and Company has supported a significant fellowship program in the chemical and biological sciences. This program is designed to stimulate interest in fields of study requiring knowledge of more than one science. The fellowships under this program therefore are designed to give special training to young men and women who have demonstrated marked ability in research in chemical or biological science and who wish to broaden their fields of investigational activity.

A third program is being supported by the Radio Corporation of America and was inaugurated recently. It is the purpose of these fellowships to give special training and experience to young men and women who have demonstrated marked ability in the general field of electronics. Their preliminary experience may have been either in the field of electrical engineering or physics. Although the applicants need not have completed more than one year of graduate work, they should have demonstrated marked ability for graduate work. These fellowships are open only to United States citizens. The fields of study to be undertaken are in the sciences underlying the general science of electronics. Stipends range from $1,600 to $2,100 per annum. Appointments are for one year, but renewable for a second year and in exceptional cases for a third year.

Further details concerning these programs may be obtained from the National Research Council Fellowship Office, National Research Council, 2101 Constitution Avenue, N. W., Washington 25, D. C.

RPI Nuclear Laboratory. A new nuclear chemistry laboratory is being equipped by Rensselaer Polytechnic Institute, Troy, N. Y., to augment its nuclear science and engineering program. The new laboratory will be opened to students of the graduate school in February. Facilities will be provided by the new laboratory for training and research in connection with the course in nuclear chemistry inaugurated by RPI in September. This course is under the direction of Doctor H. M. Clark, assistant professor of physical chemistry, who has returned to RPI following a year's leave of absence spent at the Clinton Laboratories of the Monsanto Chemical Company, Oak Ridge, Tenn. For two years during the war, Doctor Clark was connected with the Manhattan Project while serving on the staff of Yale University.

FOREIGN • • • • • •

Peru—New Radio Station. The Ministry of Public Education in Peru has inaugurated a radio station which will be operated by the ministry through the Director of Technical Education in the boys school, Colegio Industrial Estados Unidos. Regular evening broadcasts began on September 1. The station, known as *OCX4C*, operates on 6,000 kc with a power of 200 watts daily from 7 p.m. to 10 p.m. (*Foreign Commerce Weekly*).

China—Increase in Radio Rates. The Chinese Government Radio Administration is faced with the necessity of increasing rates on outgoing international messages because of the increased cost in Chinese dollars of European and other foreign exchange. Upward revision of the Chinese dollar–gold franc message cross-rate comparable to the difference between the official and open market exchange rates for these currencies is believed probable in the near future. (*Foreign Commerce Weekly*).

French Morocco—Increase in Telephones. French Morocco at the end of 1946 had 23,700 telephones in use as compared with 16,500 in 1939. The number of calls shows a rise from 15,946,000 in 1939 to 33,610,000 in 1946. At the present time there is a waiting list of 10,000 requests for telephone service. (*Foreign Commerce Weekly*).

France—Increase in Rates. The French Minister of Post, Telegraph, and Telephone has announced an increase in the rates on postal material, telegrams, and telephone service. The increase, combined with a plan for the reduction of expenditures, was the result of a proposal for reducing the ministry's annual deficit, in line with the Schumann financial project to balance the country's budget. (*Foreign Commerce Weekly.*)

NEW BOOKS • • •

"The Cherokee Project." The planning, design, construction, and initial operations of the Cherokee Dam and Reservoir (near Knoxville, Tenn.) are discussed in detail. The seventh book of a series of technical reports of the Tennessee Valley Authority, it may be procured from the Superintendent of Documents, Washington, D. C. United States Government Printing Office, Washington, D. C., 1946, 411 pages, 138 illustrations, cloth-bound, $9^1/_4$ by 6 inches, $1.50.

"The Hiwassee Project." The planning, design, construction, and initial operations of the Hiwassee Dam and Reservoir (western North Carolina) are discussed in detail. The fifth book of a series of technical reports of the Tennessee Valley Authority, it may be procured from the Superintendent of Documents, Washington, D. C. United States Government Printing Office, Washington, D. C., 1946, 367 pages, 116 illustrations, cloth-bound, $9^1/_4$ by 6 inches, $1.25.

"Electronics for Industry." Although emphasis is placed on the explanation of principles of electronics as applied to industrial equipment, this book furnishes a practical nonmathematical explanation of fundamental electronics and its applications in rectifiers, amplifiers, oscillators, basic control circuits, high-frequency induction, and dielectric heating. Industrial applications are discussed as well as basic theory of electron properties, emission, tube characteristics, amplification, and oscillation. By W. I. Bendz (M'41). John Wiley and Sons, Inc., New York, N. Y., 1947, 501 pages, cloth-bound, $8^1/_2$ by $5^3/_4$ inches, $5.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

APPLIED ARCHITECTURAL ACOUSTICS. By M. Rettinger. Chemical Publishing Company, Brooklyn, N. Y., 1947. 189 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $5.50. A practical book giving theoretical and functional uses of theory for the design of motion picture theaters, scoring stages, reverberation chambers, vocal rooms, sound stages, broadcasting and television studios, hospitals, churches, and auditoriums. A separate chapter is devoted to acoustic measurements. It should be useful to architects, engineers, and contractors.

ELEMENTS OF ELECTRICAL ENGINEERING, A TEXTBOOK OF PRINCIPLES AND PRACTICE. By A. L. Cook, C. C. Carr. Fifth edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1947. 662 pages, illustrations, diagrams, tables, $9^1/_4$ by 6 inches, cloth, $5. Numerous changes and additions have been made in this fifth edition. Discussion of control generators, mathematical representation of vectors, dry-type transformers, saturable-core reactors, and synchros has been added. The chapter on electric measuring instruments has been enlarged, and material on the fundamentals, characteristics, functions, and basic circuits of electron tubes, and the principles of application of electronic devices in industry have been included. The discussion of electric and magnetic circuits, d-c machinery, alternating currents, and a-c machinery has been revised, and new illustrations used. The book is designed to satisfy the needs of both students in the electrical field and those who are not.

ESSENTIALS OF APPLIED PHYSICS. By R. M. Frye. Prentice-Hall, Inc., New York, 1947. 322 pages, diagrams, tables, $9^{1}/_{4}$ by 6 inches, cloth, $4. An elementary physics textbook requiring a mathematical basis of algebra, geometry, and trigonometry. The general procedure of mechanics, heat, sound, electricity, and light is followed. Each chapter is summarized on the basis of definitions of the technical terms and laws introduced. The practical electrical units are used, and the electron current is employed exclusively rather than the conventional positive current.

HEAT PUMPS. By P. Sporn, E. R. Ambrose T. Baumeister. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1947. 188 pages, illustrations, diagrams, charts, maps, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $3.75. The purpose of this book is to present a technical treatment of the numerous problems involved in the application of heat pumps to building heating and cooling, to the evaporation and purification of liquids, for the drying of solids and the simultaneous chilling and heating of process fluids. Thermodynamic principles; design, specification and selection of equipment; and maintenance, operating, and installation problems of heat pumps are considered. No attempt has been made to analyze the theory, performance and design of heat pump construction. Many charts complement the text, and references to the sources of data are given at the end of each chapter.

INTRODUCTION TO THE THEORY OF EQUATIONS. By L. W. Griffiths. Second edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1947. 278 pages, diagrams, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $3.50. The important general theorems in the elementary theory of algebraic equations are developed from the particular to the general. Complicated proofs are separated into simpler parts for easier understanding, and other such clarifying procedures are used wherever it seems needful. Determinants and complex numbers also are dealt with.

KLYSTRON TUBES. By A. E. Harrison. McGraw-Hill Book Company, New York, N. Y., and London, England, 1947. 271 pages, illustrations, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, cloth, $3.50. This volume is composed of revised material from earlier publications with the addition of new information. Discussion of the components of klystron tubes, a theoretical analysis of the operation of such tubes, power supply considerations, and microwave techniques are dealt with. No design information has been included in the text. An understanding of electronic phenomena and the fundamentals of radio are a prerequisite for the effective use of this book. A glossary of terms and symbols is included.

MANUAL OF ENGINEERING DRAWING FOR STUDENTS AND DRAFTSMEN. By T. E. French, revised by C. J. Vierck. Seventh edition. McGraw-Hill Book Company, New York, N. Y., and London, England, 1947. 694 pages, diagrams, charts, tables, $9^{1}/_{2}$ by 6 inches, cloth, $3.75. This revised and enlarged edition contains the usual information on instruments, drawing, dimensioning, sketching, perspective, maps, charts, graphs, and diagrams. A new chapter on illustration has been added, the chapter on perspective was revised considerably, and the chapter on dimensioning expanded. Several new projective methods and explanations have been included. When using this volume as a text, the author suggests the use of the McGraw-Hill Text-Films which were made specially to be companion material to the book.

PHYSICS FOR STUDENTS OF SCIENCE AND ENGINEERING. By W. H. Michener. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1947. 646 pages, diagrams, charts, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $4.25. This college-level textbook covers the customary topics of mechanics, heat, sound, light, electricity, and magnetism, and requires a mathematical background including the fundamentals of trigonometry. Physical principles are stressed rather than formulas in the interest of establishing an effective groundwork for the student. Problems are provided at the back of the book arranged by topics, with references to the portion of the text discussing the underlying principles involved.

TABLES NUMÉRIQUES UNIVERSELLES DES LABORATOIRES ET BUREAUX D'ÉTUDE. By M. Boll. Dunod, Paris, France, 1947. 881 pages, diagrams, charts, tables, 11 by 7 inches, stiff cardboard, 3,200 frs. This comprehensive work presents for the use of the laboratory or research worker a collection of more than 200 useful tables covering arithmetical and algebraic operations, trigonometric expressions, exponentials, probabilities, complex numbers, constants, and conversion tables of units. The material varies from simple, general, numerical expressions to special calculations, and in more than half of the cases a graphical illustration is provided by a diagram. Interpolation methods are described, and a detailed subject index is included. Terms are carried out to eight or ten places, although five to six places or less more generally are supplied, depending on the character of the items in question.

THEORY AND APPLICATION OF MATHIEU FUNCTIONS. By N. W. McLachlan. Oxford University Press, New York, N. Y.; Clarendon Press, Oxford, England, 1947. 401 pages, diagrams, charts, tables, $9^{1}/_{2}$ by 6 inches, cloth, $12.50. Addressed to the technologist, the purpose of this volume is to give the theory of Mathieu functions and to demonstrate their application to representative problems in physics and engineering science. These applications are taken from the fields of radio, acoustics, mechanics, heat conduction, electromagnetism, and others in which oscillatory effects occur. A short historical introduction and a bibliography are included. Although not written for mathematicians, the mathematical treatment is carried out thoroughly.

VECTOR AND TENSOR ANALYSIS. By L. Brand. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1947. 439 pages, diagrams, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $5.50. The theory and simpler applications of vector and tensor analysis in ordinary space are covered, including significant applications of the concepts of dyadics, matrixes, "motors," and quaternions. Surface geometry and hydrodynamics are treated at some length in separate chapters. Nearly all of the important results are formulated as theorems in which the essential conditions are stated explicitly. There are problems at the end of each chapter.

WRITING THE TECHNICAL REPORT. By J. R. Nelson. Second edition. McGraw-Hill Book Company, New York, N. Y., and London, England, 1947. 388 pages, diagrams, tables, 9 by $5^{1}/_{2}$ inches, cloth, $3. The first part of the book presents a review of those fundamental considerations which bear on the design and composition of the report. The second gives specific directions for the setup of the report, with several illustrative reports of both the long and short form. The third outlines a systematic procedure for the critical examination of a report, and the last part suggests a series of assignments for those who wish to use the book as a classroom text. Although little changed essentially from the earlier edition, the book now contains an index.

AMERICA'S NEEDS AND RESOURCES, A TWENTIETH CENTURY FUND SURVEY. By J. F. Dewhurst and Associates. The Twentieth Century Fund, 330 West 42d Street, New York, N. Y., 1947. 812 pages, charts, tables, $10^{1}/_{4}$ by 7 inches, cloth, $5. Beginning with a survey of our wartime production and using the available reliable records of past economic changes, this volume contains basic estimates of future employment and productivity, and of population, income, consumption, and expenditure patterns of the future. The extensive statistical information is presented in over 250 tables. On the basis of this information concerning previous years, the demands and needs of 1950 and 1960 are estimated. Detailed analyses are presented of such items as passenger traffic, crop yields per acre, and retail purchases of various commodities. Containing over 800 pages, including a 20-page index, this comprehensive study of our entire economic system is intended as a basic framework for future planning.

COLLEGE PHYSICS; MECHANICS, HEAT, AND SOUND. By F. W. Sears, M. W. Zemansky. Addison-Wesley Press, Inc., Cambridge 42, Mass., 1947. 383 pages, illustrations, diagrams, charts, tables, $9^{1}/_{4}$ by 6 inches, cloth, $6. Constituting the first part of a college physics text, this volume covers the subjects of mechanics, heat, and sound. It is intended for students whose mathematical background is restricted to algebra and trigonometry. The emphasis of the book is on physical principles. Historical background and practical applications are of secondary importance. The treatment of the subject matter is held within a scope which may be covered in one semester.

CONDUCTION OF HEAT IN SOLIDS. By H. S. Carslaw, J. C. Jaeger. Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., 1947. 386 pages, diagrams, charts, tables, $9^{3}/_{4}$ by $6^{1}/_{4}$ inches, cloth, $8. Based on the earlier "Introduction to the Mathematical Theory of Conduction of Heat in Solids," this volume has been rewritten and brought up-to-date. The general theory is given together with its application to the linear flow of heat and to the flow of heat in a rod, rectangular parallelepiped, circular cylinder, sphere, and cone. The Laplace Transformation method of dealing with problems in the conduction of heat is used instead of the older method of contour integrals. The authors have attempted to make this edition useful to engineers and physicists without altering its character as a mathematical work. There are more than 400 footnote references.

COST ACCOUNTING, FUNDAMENTALS AND PROCEDURES. By C. L. Van Sickle. Second edition. Harper and Brothers, New York, N. Y., and London, England, 1947. 889 pages, diagrams, charts, tables, $9^{1}/_{2}$ by 6 inches, cloth, $7.50. Designed to show the relationships between cost accounting and the fields of factory management, marketing, and administrative management, this book covers such topics as cost applications, factors, elements, systems, and adaptations. Budgetary control and general cost accounting are discussed. This second edition has been revised slightly by the addition of a chapter on cost accounting and cost control, and the omission of the chapter on mechanical appliances used in compiling costs. Other revisions affect the chapters on standards and flexible budgets, provide for the condensation of three chapters on market cost systems into one, and the condensing of the material on the general principles of budget control. More than 200 pages are devoted to practical, illustrative problems. There is a bibliography.

DICTIONARY OF ELECTRICAL ENGINEERING. By G. W. Stubbings. E. and F. N. Spon, Limited, London, England, 1945. 219 pages, diagrams, tables, $7^{1}/_{2}$ by 5 inches, cloth, 10s.6d. Composed of definitions of terms relating to the theory and practice of heavy electrical engineering, this small dictionary is intended for the use of students, practical engineers, and all those whose work brings them into contact with the field. A concise explanation of the more important technical terms is given. Since this book is published in England, British terminology is used.

ELECTRIC FURNACE DESIGN, MANUFACTURE AND APPLICATION IN GERMANY. PB 32566. Reported by W. J. Millar, V. O. Cutts, J. C. Harris, J. McDonald. 109 pages, $3.
ELECTRICAL CONTACTS. By F. R. Hensel. PB 32586. 24 pages, $1.
GERMAN GLASS INDUSTRY, WITH PARTICULAR REFERENCE TO GLASSES USED IN BUILDING. PB 34021. Reported by W. L. Patrick, J. H. Waggoner, A. R. Green, M. Parkin, T. Parry, J. H. Partridge. 155 pages, $4.
GERMAN SCIENTIFIC ESTABLISHMENTS. Report by L. E. Simon. PB 19849. 228 pages, $4.50. Reproduced with permission by Mapleton House, Publishers, 5415 Seventeenth Ave., Brooklyn 4, N. Y., 1947. Illustrations, diagrams, charts, tables, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, paper. Of the series of technical, industrial and intelligence reports released since the war, these four contain the following information:
Electric furnace design: resistance heated furnaces and low frequency induction furnaces, including their manufacture and application in Germany.
Electrical contacts: the composition, properties and production of contact alloys.
German glass industry: technical developments in the manufacture of sheet window, plate, and safety glass.
German scientific establishments: work done at German research centers on ballistics, aerodynamics, and rockets.

PAMPHLETS • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Mercury Lamps in Industry. (Y-729) This folder tells a story of mercury lamps as a production tool. It states the facts about using mercury lamps for industrial lighting in medium and high-bay industrial interiors where frequently they are used because of their high light output. The booklet also contains physical and electrical specifications of the *AH-9* (3,000-watt) and *AH-1* (4,000-watt) mercury lamps. Copies of the booklet may be obtained from the General Electric Lamp Department sales district offices.

Improved Pickling and Neutralizing With Oakite Materials. A report giving data on specialized acid inhibitors and neutralizing materials used in pickling operations on iron and steel. Contained in this report is a special section including graphs showing the action of these Oakite acid pickling inhibitors in reducing metal loss. A comparison chart and table show how these materials reduce acid consumption and extend life of pickling solutions by lowering iron sulphate build-up. The report is available from Oakite Products, Inc., 157 Thames Street, New York 6, N. Y.

Rototrol. What Rototrol is, what it does, and how it works, is outlined in this booklet on automatic operations for electric equipment. Seven pages of technical information also are included giving additional data on the theory, design, and operating principles of standard Rototrols and several frequently-used modifications. Copies of the booklet (*B-3649*) may be secured from the Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

Articles on Diamonds. A bulletin containing abstracts of articles dealing with properties and industrial applications of diamonds, together with notices of patent and patent applications, is published by the Industrial Diamond Information Bureau, Industrial Distributors (1946) Ltd., St. Andrews House, 32–34 Holborn Viaduct, London, E. C. I, England. Copies of the bulletin are free.

1946 Supplement to the Bibliography and Abstracts on Electrical Contacts. Through the work of its Committee B-4 on Electrical-Heating, Resistance and Related Alloys, The American Society for Testing Materials has issued an original Bibliography on Electrical Contacts and three supplements. The 1946 supplement became available August 1947, the latest 26-page supplement gives replacements and new references for 1940–44 and covers publications in 1945 and 1946. This third supplement may be procured from the ASTM headquarters, 1916 Race Street, Philadelphia 3, Pa., at 75 cents per copy. The original bibliography is available at $5, 148 pages. The first and second supplements at $2 per copy and 50 cents per copy, respectively. The original bibliography with all three supplements is $6.50.

Continuous Blowoff Systems. This booklet describes five different flash-tank and heat-exchanger systems for recovering the otherwise wasted heat in boiler blowoff water. The flash principle permits regeneration of low pressure steam for feedwater or plant heating. Remaining heat in the concentrated blowoff water is transferred to incoming feedwater through a heat exchanger. Multiple tanks may be used for flashing of steam at different pressures. The pamphlet is available from Cochrane Corporation, 17th Street and Allegheny Avenue, Philadelphia 32, Pa.

Heat Losses in Furnace Mining. Simplified methods of quickly determining the efficiency and economics of various types of refractory linings for industrial furnaces are contained in the reprint of a lecture given by the head of the engineering and service department, refractory division, The Babcock and Wilcox Company. Copies are available on request to the company's advertising division, 85 Liberty Street, New York 6, N. Y.

Facts in Figures About Atlanta. A booklet published by the Atlanta Chamber of Commerce presenting information about the Southern market. Facts about Atlanta include transportation facilities, aviation data, communication facilities, United States Government activities in Atlanta, electric power and fuel, education, and city government. Pointing out the advantages of the Southern market, the booklet suggests that Atlanta is the logical place from which to serve that area. Copies may be secured from the Industrial Bureau of the Atlanta Chamber of Commerce, Atlanta, Ga.

Industrial Management Progress. "Progress in Scientific Management—1945–47." A check list of publications reporting progress in business and industrial management since the end of World War II in personnel and industrial relations, office management, production, marketing, financial management, insurance, packaging, and general management has been released by the American Management Association, 330 West 42d Street, New York, N. Y.

X-Ray Diffraction Camera for Microtechniques. A folder showing construction and application of a new camera especially adapted to fiber analysis. Diffraction phenomena from selected microscopic regions of solid materials can be handled with the new camera. Replaceable collimator systems limit beam diameters from 100 to 25 microns. Sample diffraction patterns are shown for unstretched polyethylene and stretched polyethylene. Available from North American Phillips Company, Inc., 100 East 42d Street, New York, N. Y.

Nickeloid Metals Fabrication Handbook. Data and practical fabricating suggestions relative to the proper handling of prefinish nickeloid metals. The booklet illustrates and describes proper bending, blanking, drawing, etching, forming, riveting, seaming, soldering, and welding operations involved in the successful handling of these metals. General information is included as to the kinds, styles, and patterns available in the N-M line of metals. Properties, sizes, weights, gauges, and conversion factors are charted. Available to members of the metal fabricating field from American Nickeloid Company, Peru, Ill.

TVA. How the apprenticeship program at the Tennessee Valley project is conducted is described in a 67-page report. Included in the report is an explanation of the functions of the central and crafts committee: qualifications, selection and tests of applicants for training; work processes in which apprentices are trained on-the-job; classroom curriculum; time required in each step of the training; apprentice wage rates and veterans benefits under the G.I. bill; periodic examinations; ratio of apprentices to journeymen; apprentice record keeping systems; apprenticeship agreements and certificate of completion. The report contains 14 exhibits including administrative and organization charts, sample record keeping forms, work process analyses, and statistics of apprentices in training since the program first was established. Copies of this report may be obtained free of charge from the Apprentice Training Service, United States Department of Labor, Washington 25, D. C.

NEMA Standards for Small-Power Motors, (Publication 47-121). This publication includes all standards for small-power motors which have been developed by the National Electrical Manufacturers Association up to August 1, 1947, and consists of excerpts from the NEMA Motor and Generator Standards, Publication 45-102. Information concerning construction, test, performance and manufacturing of universal, a-c, and d-c small-power motors is included. A revision service is provided, at no additional charge, to all purchasers of the standard. National Electrical Manufacturers Association, 155 East 44th Street, New York, N. Y., 8 by $10^1/_2$ inches, 76 pages, $2.